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Vol. 37 FEBRUARY, 1955 No. 2

SURGERY

A Monthly Journal Devoted to the Art and Science of Surgery

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Vol. 37, No. 2, February, 1955. Surgery is published monthly by The C. V. Mosby Company, 3207 Washington Blvd., St. Louis 3, Mo. Subscription price: United States, $14.00 a year; Canada, $14.50; Foreign, $15.50. Entered as Second-Class matter January 20, 1937, at the Post Office at St. Louis, Missouri, under the Act of March 3, 1879. Printed in the U. S. A.

SURGERY

VOL. 37 FEBRUARY, 1955 NO. 2

Original Communications

Society for Vascular Surgery
(concluded)

THE USE OF RIGID AND FLEXIBLE PLASTIC PROSTHESES FOR ARTERIAL REPLACEMENT

CHARLES A. HUFNAGEL, M.D., WASHINGTON, D. C.

(From Georgetown University Medical Center)

ALTHOUGH we have long been staunch advocates of the use of arterial grafts for the reconstruction of major arteries[1, 2] and, indeed, were prime movers in establishing both the technical details and the concept of arterial replacement by grafts,[3, 4] we have nevertheless been fully aware of certain inherent problems associated with the use of such grafts. We have devoted a great deal of time and effort to the simplification of the procedure for obtaining and preserving such grafts for long periods of time. Some of these measures have included the use of rapidly frozen grafts, a simplified technique for freeze-drying and sealing of such grafts, and, more recently, a method for the sterilization of grafts taken without aseptic precautions prior to the freeze-drying. We[5] have also extensively investigated the possibilities of the use of freeze-dried heterografts, sterilized by the ethylene oxide method, and have used these in a number of patients with excellent results. In spite of these advances we have continued to look forward to the possibility of using material of nonbiologic origin which would have the advantages of being completely available in all sizes and shapes in all areas without the difficulties of having to secure a graft of human or animal origin and without the necessity for the meticulous processing involved in even the simplest currently available methods. We further recognize the fact that although the grafts which were implanted in patients early have shown little evidence of degenerative change, certain animal experimentation has shown, in at least some cases, undesirable changes in the graft with long periods of time. The work of Deterling and co-workers[6] and ourselves[7] has given further impetus to our desire to obtain prostheses which would obviate the problem of long-term degenerative changes.

The search for a suitable prosthesis was actually begun about 1944 almost concurrent with our early work with arterial homografts. The report[8] of the

Read at the eighth annual meeting of the Society for Vascular Surgery, San Francisco, June 20, 1954.

first successful permanent intubation of the aorta was made to the Clinical Congress of the American College of Surgeons in 1946. All the early work was concerned with the use of rigid tubes substituting for a major arterial segment. Carrel[9] and others had attempted previously to insert such implants, but none of these had been permanently successful. Our work with the use of rigid prostheses has continued, and in the intervening period, we have used more than 400 such implants in animals and patients. As a result of this work we feel that we can routinely replace segments of large vessels with reproducible success. As a result of this work we have laid down certain criteria which we believe are of importance in the successful establishment of such a rigid prosthetic substitute.

First, the material employed should be relatively biologically inert. We use the term "relatively" because it is impossible to evaluate exactly in a quantitative manner the reaction of the host to an implant, and the insertion of any material of a different consistence than the adjacent tissue and its relation to movement have a direct bearing upon the relative host response.

Second, the material must have adequate strength; this implies that it must be able to withstand all stresses to which it can be normally subjected in the body, and that it will not deteriorate with time to a degree which will be harmful. This must also necessarily include resistance to the continued contact with fluid at body temperature and the chemical elements with which it is in contact in the tissue fluids.

Third, it must resist clotting. In our early work we were attracted by the concept of Neubauer and Lampert[10] and Hirschboeck,[11] who showed that in vitro blood coagulation was related to surface properties of the material with which blood was in contact. It was demonstrated that coagulation of blood was inhibited when in contact with surfaces which were not easily wet by it. This surface phenomenon is apparently also related to surface charge as well as to the polish or the smoothness of the surface, in addition to its "wettability," or as Walter, Murphy, and associates[12] have termed it, the property of "hemo-repellency." We have continued to be impressed with the validity of this concept, and it is interesting to note that this concept has been adopted on a wide scale to many applications where it is desirable to inhibit the coagulation of blood and is more and more widely accepted.

Fourth, the internal surface of the prosthesis must be extremely smooth. It has been found that major irregularities in the surface of the blood conducting tube, particularly those with sharp or irregular edges, greatly increase the likelihood of clotting.

Fifth, there must be a smooth junction between the vessel and the tube in order to minimize turbulence and to prevent the laying down of fibrin at the tube-vessel junction. The leading edge of the tube must be so tapered as to form a smooth continuing line with the interior of the vessel. The leading edges must be thin and tapered, but not cutting. The tube must be inserted in such a way that a sharp angulation of the tube with the vessel at the points

of junction is not produced. The forward thrust and the recoil of a rigid tube against the intima of the vessel can produce traumatic arteritis, if this latter point is not observed.

Sixth, the anastomosis between the tube and the vessel must be effected by a method which does not produce necrosis of the arterial wall at the point of junction. We have postulated that this is best done by utilizing the principle which we have termed "multiple-point fixation." The principle of "multiple-point fixation" has been delineated elsewhere; essentially it consists of securing fixation by a multiple-point pressure on the circumference of the arterial wall, avoiding continuous circumferential pressure. In an effort to delineate this problem further, we have utilized many materials to make tubes which approach the ideal. Among the materials which have been used are methyl methacrylate (Lucite, Plexiglas), polyethylene, Teflon, Kel-F, nylon, stainless steel, Vitallium, and other metals. In addition, we have utilized these and other materials coated with various forms of silicone. More recently, we have utilized silicone rubber. However, of all these materials, methyl methacrylate has been outstanding. Its hemo-repellency, as tested by ourselves and others, has been well maintained after prolonged tissue contact, and in large vessels down to the size of the canine aorta we have been able to maintain patency regularly.

Our experience with Teflon has been somewhat more limited, but it has also been good. Nylon and several forms of polyvinyl compounds have absorbed large quantities of water after being implanted and have routinely thrombosed. In spite of theoretically excellent properties, our experience with polyethylene has not been entirely satisfactory. We have found that after prolonged tissue contact, clot tends to be laid down within the tube and ultimate thrombosis is very common after long periods of time.

Tubes of methyl methacrylate have been utilized routinely in the anastomosis made with rings of nylon. The nylon is relatively inert in tissue and when it is not in contact with a blood surface its use is satisfactory. Tubes employed in this way have been used to replace the abdominal thoracic aorta of dogs for periods up to six years with complete maintenance of patency. These tubes have varied in length from 2 cm. to 10 cm. In such instances in which longer tubes are used, it is necessary to utilize a tapered tube in order to secure a proper fit at both ends. This can be done quite satisfactorily. We have also utilized Y tubes and tubes with single branches. It is interesting to point out that the principle of multiple-point fixation can be applied not only to the normal vessel, but to those in which a great deal of atherosclerotic disease is present. In several such hundred applications there has been no instance of necrosis of the vessel wall or rupture of the vessel due to the method of fixation. The type of tube with its corresponding rings is shown in the accompanying illustrations. It is of extreme importance that the tube accurately fit the artery into which it is placed. Considerable delicacy in the manipulation of the vessel is necessary when placing the tube, as in any arterial anastomosis. It is quite possible to tear the vessel, if one attempts to use a tube which is too large. It is also possible to strip the endothelium from

the vessel as the tube is being inserted. This causes the endothelium to roll up at the tube-vessel junction, causing thrombosis. Instruments have been devised to hold the tube firmly so that intubation is simple and rapid, and also to close the rings; intubation may be accomplished rapidly. Fig. 1 shows the ring-closing instrument, and Fig. 2 shows a rigid tube with its ring.

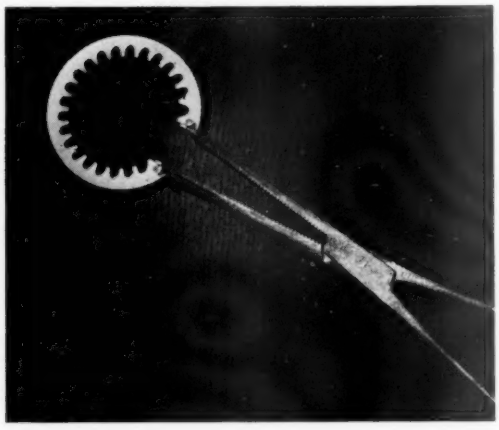

Fig. 1.—The ring-closing instrument is shown engaged in the nylon ring.

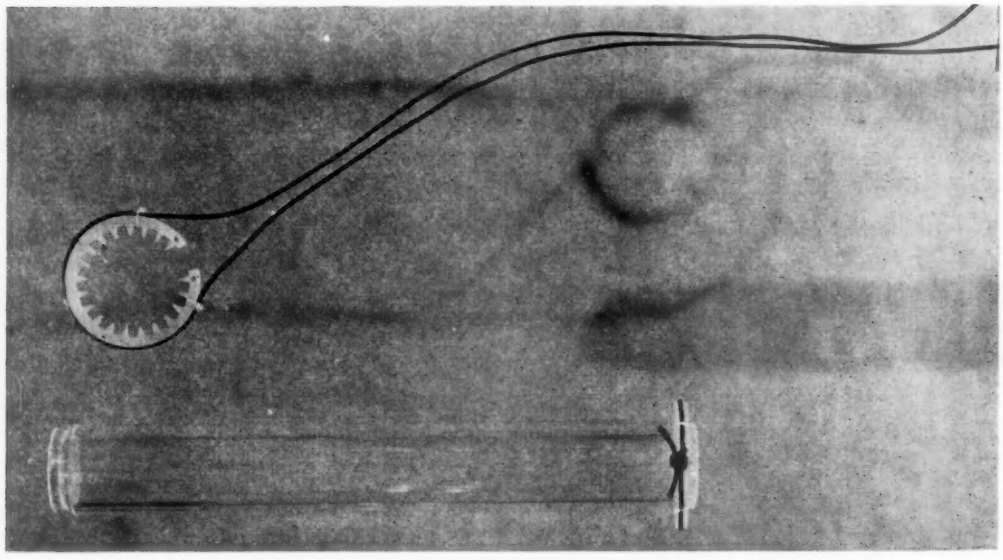

Fig. 2.—Methyl methacrylate arterial tube and its nylon rings. One ring is shown illustrating the teeth which produce "multiple-point fixation." The second ring is shown in place on the tube.

The method employing a rigid tube and multiple-point fixation has been extremely satisfactory in selected locations. The rigidity of the tube makes its application impractical in areas where the prosthesis crosses a major flexion crease. Similarly, the method is difficult in application when multiple branches of variable size, shape, and angle occur. Because of the necessity of close approximation of size of the prosthesis to the vessel above and below, it is

necessary to have a very large selection of tubes, varying both in diameter and length in order to meet the numerous conditions. In very small vessels where the ratio of the thickness of the prosthetic wall in relation to diameter becomes great, factors of increasing turbulent flow and so on make its use less desirable. In contrast to the disadvantages, in sites where it is applicable, it offers an extremely simple and highly satisfactory method. Thus, in the aorta itself where the range of the diameter is relatively limited and where major branching is relatively constant, this method has its ideal application.

FLEXIBLE PROSTHESES

Being fully aware of the limitations of rigid prostheses, and postulating in our original criteria that in addition to those factors listed previously that the tube should be flexible, and the flexibility should ideally approach the flexibility of a normal vessel, we have continued to investigate the possibilities of such flexible materials. Such flexible prostheses may be of two general types. First are those in which the prosthesis is sutured to the blood vessel by customary methods of arterial anastomosis. The second type is that in which the prosthesis itself is flexible, but in which the anastomosis is effected through the use of multiple-point fixation by having a rigid end to the prosthesis.

The work of Voorhees, Jaretzki, and Blakemore[13] using Vinyon-N-type cloth has demonstrated the feasibility of flexible woven materials.

This study comprises a survey of the method of using cloth-type prostheses. The materials used have included Vinyon, nylon, Orlon, and Dacron—both treated and untreated. We have tried to select the types of materials on the basis of adequate flexibility, regularity of the fiber, relative water repellency, and on the basis of the type of weave. We have felt that it would be most advisable if the untreated material were of such character that it would not leak excessively when implanted. These experiments have been carried out over the period of the past two years. In the early work with Vinyon-N it was found that this material leaked blood excessively to a degree where it was difficult to control.

Blakemore and Voorhees have advocated the use of preclotting so that a deposit of fibrin would be laid in the interstices of the cloth so as to prevent leakage. While this is helpful, we felt that it is not desirable to initiate laying down of fibrin in the graft. Of the materials which we have tested to date, Orlon seems to combine the properties of lack of clotting, permanent patency with ease of handling, and lack of bleeding. In addition, the Orlon strands are extremely uniform and smooth, and it is quite nonreactive in tissue. We have used a 75 by 100 or 100 by 100 weave of type-81 Orlon fiber. With many types of nylon we have found that clotting has been a major detriment. Some types, such as some forms of nylon taffeta, have been quite satisfactory.

It is desirable when using all types of cloth to wash them thoroughly and to rinse them to remove all cleansing material. Washing is necessary because as the fibers are processed a certain amount of oil and foreign matter accu-

mulates on the surface of the fiber. This is a highly variable factor and can be eliminated only by a standard method of treatment prior to their use. It, naturally, is important in the use of all prosthetic devices that foreign material be removed completely, and it is a matter which is frequently overlooked. The tubes which are used have been made both in straight forms and in branched tubes, including Y bifurcations. Tubes are formed by sewing the material with a single seam, slightly flaring the ends so they can be turned back and doubled at the ends as shown in Fig. 3. In this way, varying lengths can be obtained without cutting the seam. The seams are sewn either by hand, using an extremely fine needle with Orlon or nylon thread, or by using a sewing machine with an extremely fine needle. The materials are thoroughly washed with a detergent and then rinsed through at least three rinses of distilled water. They are then autoclaved in the standard method for fabric. The grafts are inserted by the usual standard everting suture technique, using 00000 silk. We have used these in the abdominal aorta of dogs in the experimental work primarily since we felt that this area represented an adequate test for moderate-sized vessels. The grafts have been 5 cm. in length.

Fig. 3.—Orlon tubes of straight tapered type and of the bifurcation type are shown with the ends cuffed ready for use.

Further tests of the grafts have been made by implanting them in the thoracic aorta; grafts here have varied from 5 to 10 cm. in length. In our early experience, failure due to thrombosis was encountered in a number of instances because it was not recognized that the prostheses must be clean,

and that wrinkling of the prostheses at the junction of the suture line sometimes lead to clotting. A number of experiments were also made in which the Orlon was coated with silicone, but this seemed to contribute nothing to the end result; and early in our experience with this method we also had some trouble because of inadequate washing of the graft to remove the acid formed by the siliconing process. In the abdominal aorta we now can expect from 90 to 95 per cent successful grafts at the end of six months. Clotting, when it occurs, tends to occur relatively early and has usually been due to improper fit of the graft or to inadequate estimation of length of the graft so that the graft has had excessive angulation. After the prosthesis has been placed by the suturing and the blood is allowed to enter the tube, no major bleeding occurs although there is slight oozing occasionally from some prostheses due to variation in the weave of the cloth. Thus, it will tend to sweat a few drops of blood through the interstices before the area becomes completely dry. Total blood loss after such a prosthesis has been utilized in the aorta of the dog usually amounts to only these few drops. When the graft is used in the thoracic aorta the bleeding may be slightly greater, but it still amounts to an insignificant amount of blood. In contrast to this, some types of nylon and Vinyon tend to leak a great deal. The process of observation of the implants has been followed by taking specimens at varying intervals from one day to one year, following operation. The process is similar with several types of cloth, and varies only in the amount of reaction to the implant and to the amount of fibrin which is deposited on the inside of the graft.

The process may be briefly described as follows: Following the placement of the tube graft of Orlon after twenty-four hours, one finds only a very thin layer of fibrin deposited on the surface, and this fibrinoid material is quite smooth and apparently is quite resistant to further clotting. The amount of fibrin varies with the cloth, being very thin with Orlon. As the process gradually progresses, this fibrinlike material is invaded by one or two cell thicknesses of flattened cells on the surface of which is an endothelial-like layer. Islands of these cells appear throughout the graft and gradually spread to cover the whole graft. At the end of approximately ninety to 120 days the graft is covered completely on the inside, and on the outside of the cloth there is laid down another layer of fibrous tissue which is four to ten cells in thickness. In some cases there tends to be separation into definite layers, but this is more marked with nylon than it is with Orlon since the actual number of cell layers is much less in the Orlon-type material. The gross appearance of the inside of the vessel is shown in figures which show the progression of the process. Following the completion of the process it tends to remain quite stable and does not appear to undergo any further major change. The elasticity of these grafts does not equal that of the normal vessel, but there is some recoil in diastole.

Following the successful use of these grafts over the period of the last year in animals, fifteen such grafts have been implanted in patients. These have been utilized primarily for resections of aneurysms of the aortic bifurca-

Fig. 4.—Abdominal aortic aneurysm exposed at operation. The inferior mesenteric artery is shown ligated and divided.

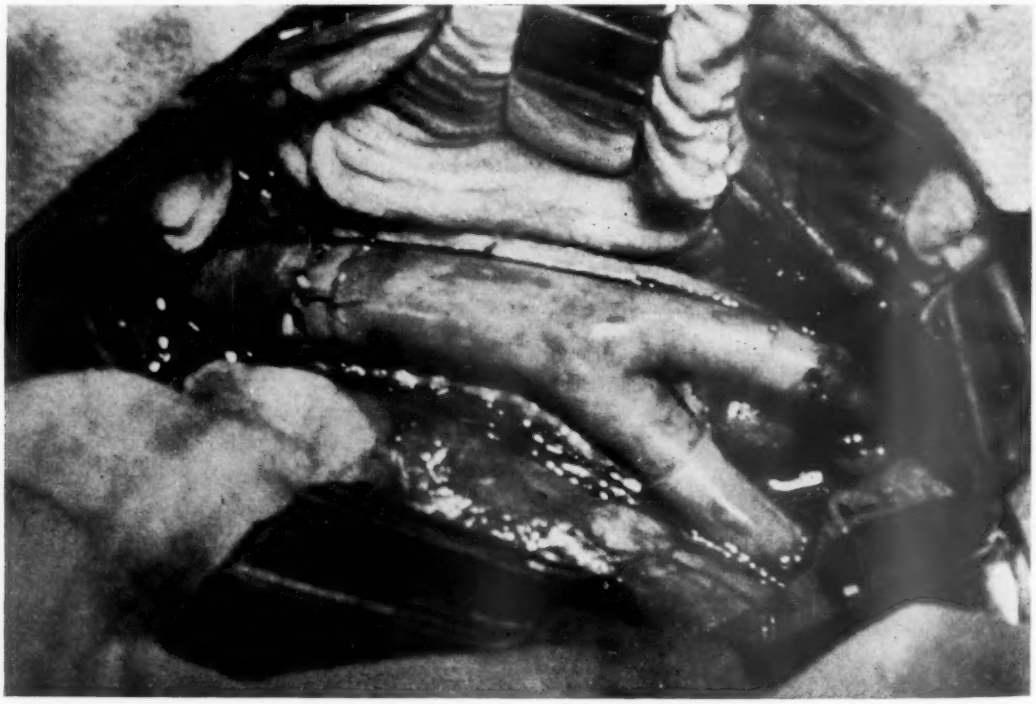

Fig. 5.—The aneurysm has been resected and aortic continuity restored by an Orlon prosthesis.

tion and for aortic bifurcation occlusions. There have been no failures in this group and no complications due to the graft. All have maintained adequate peripheral pulses and these grafts have now been in place for approximately ten months. An illustration of such a graft implanted after resection of the aortic bifurcation for aneurysm is shown in Figs. 4 and 5. It is interesting to point out that these grafts are more difficult to handle technically than homografts since the elasticity of the Orlon is less than that of a homograft. Nevertheless these grafts are highly adaptable, and the graft can be sewn at the operating table to meet the immediate situation and to adapt them to the conditions which must be met in the individual case.

The advantages of such a readily available graft substitute are quite apparent. The ability to sterilize this material by autoclaving offers additional advantages and assures a ready supply of such grafts for every need. We do not, however, at the present time recommend that these grafts be used to bridge major flexion creases.

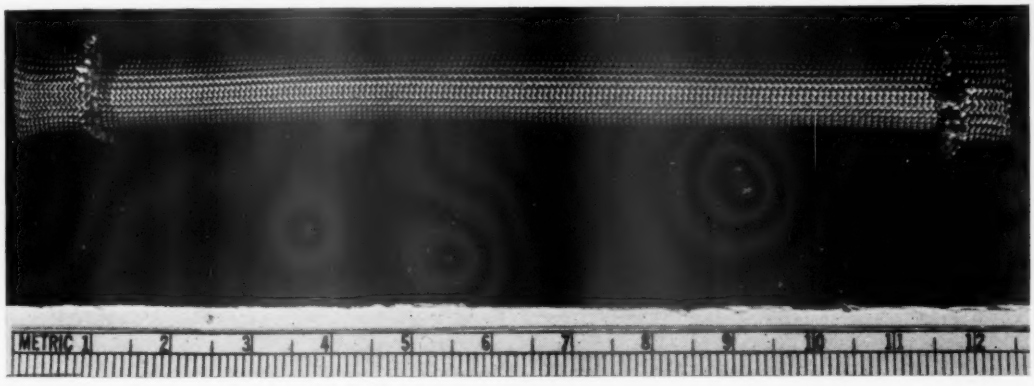

Fig. 6.—Seamless tube with cuffed ends. This type of tube with its woven construction is more easily anastomosed to the host artery.

We have used these grafts in patients with aortic aneurysms, aortic occlusions, traumatic and arteriosclerotic occlusions of the superficial and common femoral arteries below the inguinal ligament, and in one case of trauma to the brachial artery with destruction of considerable collateral so that loss of the arm appeared imminent. Circulation was completely restored in these instances and has been maintained over a period of sixteen months. It appears quite probable from pilot studies that by changing the type of weave from the standard weave which has been used in this type of material to date it will be quite possible to obtain seamless tubes, both as straight and bifurcated, or branched tubes with considerable elastic recoil by using a diagonal-type weave, thus greatly improving the resiliency and adaptability of the grafts. We have joined Dr. Blakemore and his colleagues in a project to produce such materials. We have already utilized obtainable straight-weave seamless tubes, but have not found them greatly superior to the types of tubes which we have constructed with a single seam. The advantage of the seamless woven tube primarily lies in the type of weave which is obtainable under some

circumstances. (Fig. 6.) The presence of seams is not in itself objectionable except, at the point where seams occur at the end, the suture must be quite carefully placed to approximate the slightly stiffened area.

CONCLUSIONS

Rigid prostheses have been extremely useful in certain locations and the work presented outlines the conditions under which they may be employed. When rigid prostheses are utilized, the application of the principle of multiple-point fixation is extremely valuable. The use of cloth-type prostheses offers a valuable adjunct to the problem of major arterial reconstruction. An Orlon-type cloth has been described which has given highly satisfactory results, both experimentally and clinically. We have also combined the use of intubation principles with the use of flexible cloth-type tubes, that is, using multiple-point fixation to place the cloth-type prosthesis. This is done simply by inserting a V-type ring under the turned back edge and fixing it with a nylon ring in the usual fashion. Further results of this work will be reported elsewhere.

Fifteen cases are noted in which highly satisfactory clinical results have been obtained over a period of sixteen months.

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EXPERIMENTAL FROSTBITE: AN INQUIRY INTO THE EFFECT OF RAPID THAWING IN THE ACUTE STAGE*

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LOUIS XIV, in his order for the inspection of the Western posts on June 30, 1707, noted that, as there was no surgeon at Detroit, the sick were cared for by Madame Cadillac and her daughter. It was in the old French tradition that the lord and lady of the manor looked after the health of their dependents. The armamentarium of the early French habitants consisted of a knowledge of European herbal remedies supplemented by the red man's lore. Among the medicinal herbs in use were garlic used as a preventive against cholera, wild angelica for digestion and general health, fresh spruce bark for ailing kidneys, and clear golden pitch of fir balsam, the native Algonquin remedy, for frostbites and sores.[1]

Certainly these early settlers, and especially their Indian contemporaries, knew well the importance of preventing frostbite. Probably the Indians, because of better acclimatization and a more instinctive knowledge of survival under the conditions in which frostbite occurs, were the more successful in avoiding this lesion. Indeed, they probably knew for generations what the United Nations' forces learned in Korea the hard way. If, then, we are to have as our thesis that nothing new has been added to medical science in so far as the prevention of cold injury is concerned, what then of treatment once frostbite has occurred? Unfortunately, in 1954 we have no medicine which can be proved to be superior to clear golden pitch of fir balsam.

Because cold injury is so important in modern life and could constitute the deciding factor in future military operations in the Arctic zone, it is important that we examine in a critical fashion our knowledge of frostbite. The modern medical literature contains a number of reports of experiments which purport to show that anticoagulants, sympathetic block, vasodilators, and rapid thawing are of benefit in the treatment of the acute stage of frostbite. However, reports in the literature are sufficiently conflicting to cause confusion.

RAPID THAWING

Recent experimental observations on rapid thawing in the acute stages of frostbite are not in accord with early clinical observations. For example, Shumacker and Finneran[2] found that under the conditions of experiments performed by them such "experiments demonstrate remarkable efficacy of rapid

Read at the eighth annual meeting of the Society for Vascular Surgery, San Francisco, June 20, 1954.

*This study was awarded the Frederick A. Coller Award by the Committee on Trauma and Nutrition, Michigan Chapter, the American College of Surgeons, 1953.

thawing in the early treatment of experimental frostbite in the tails, feet, and ears of a number of species.'' Many decades ago, however, Baron Larrey, who was Napoleon's surgeon during the Russian Campaign, found that rapid thawing increased the damage wrought by frostbite in his soldiers. In speaking of the retreat from Russia,[3] he told a dreadful story of the suffering from cold. He said that ''persons were seen to fall dead at the fires of the bivouacs. Those who approached them sufficiently near to warm their frozen feet and hands were attacked by gangrene.'' Larrey advocated, in cases in which the skin is livid and not yet gangrenous, frictions with snow, or rubbing with towels soaked in ice water. He stated that if these fail, the part should be ''plunged in cold water in which it should be bathed until bubbles of air are seen to disengage themselves from the congealed part. This is the process adopted by the Russians for thawing a fish.''

While we, of course, are not going to recommend prolonged cooling or friction to areas injured by cold, it is of interest that the experiments to be reported support the clinical observations of Baron Larrey during Napoleon's Russian Campaign, rather than many modern observations from the experimental laboratory.

EXPERIMENTAL METHODS

Thirty adult rabbits weighing approximately 2 to 2½ kilograms comprise this series. Fifteen served as controls, in that after severe frostbite was produced, the frozen extremity was allowed to thaw at room temperature. The remaining fifteen were treated by rapid thawing at body temperature.

The right hind leg of each of the thirty rabbits was first prepared by removing most of the hair with an electric clipper. Remaining hair was removed by application of a barium sulfide depilator. Previous experience (Arena, Gerbasi, and Blain[4]) showed that exposure to the frostbite-producing medium should be made as soon as possible. A delay of even twenty-four hours results in the growth of a close-knit coat of hair which has sufficient insulating qualities to prevent the production of a standard frostbite lesion. Intravenous Nembutal, 32 mg. per kilogram, was used for anesthesia. After this preparation the extremity was immersed for thirty minutes in a mixture of acetone and solid carbon dioxide which was maintained at $-10° \pm 2°$ C. (approximately 14° F.). This constitutes approximately 300 degree minutes of exposure and produces a standard lesion. At the end of the exposure the control was returned to his cage, and the anesthetic repeated in the animals to be treated. With the anesthetic dose utilized for freezing, the maximum effect of the intravenous anesthesia was slightly greater than thirty minutes. If the anesthetic were not repeated after freezing (before rapid thawing), the treated animal experienced pronounced pain when the affected area was exposed to the thawing medium. Immediately after exposure to the cold, the frozen extremity of the animal to be treated was immersed for thirty minutes in a constant water bath maintained at body temperature. Alternate controls and animals subjected to rapid thawing were studied.

RESULTS

On freezing, the affected area showed marked venous spasm with dilatation and congestion of the superficial veins above the line of freezing. As a rule, a hyperemic zone approximately 1.0 cm. in width, which was previously described (Arena, Gerbasi, and Blain[4]), at the junction of the normal and frozen areas was present. At cessation of freezing there appeared to be a reduction in the size of the affected area over the corresponding normal, nonfrostbitten area. In the control, the thawing at room temperature resulted in hyperemia with slowly increasing edema in the next twenty-four hours (Fig. 1). In the treated animals, immediate changes occurring within the first five

Fig. 1.

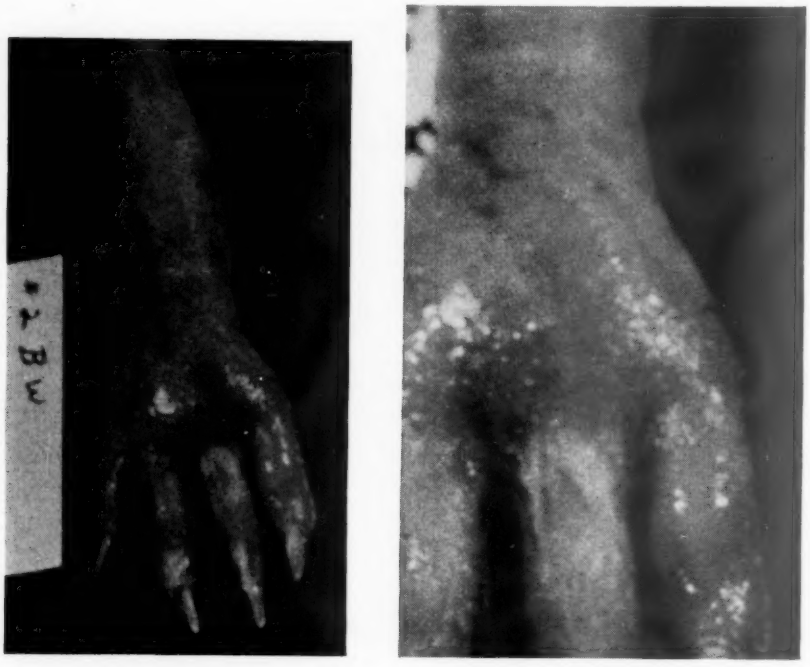
Fig. 2.

Fig. 1.—Extremity of rabbit prior to exposure to freezing medium. Note that there is almost complete absence of protecting hair.

Fig. 2.—Extremity immediately after thirty-minute exposure to −10° ±2° C. At this stage the affected areas of treated and control animals appeared identical.

minutes were striking. Within these five minutes scattered petechiae appeared in the affected area, and in fifteen minutes the entire area was covered with such petechiae, demonstrating moderate to moderately severe hemorrhage into the subcutaneous tissues. The edema began to appear during this same interval and increased rapidly, so that at the end of thirty minutes the frostbitten area was four to five times larger than normal in size (Fig. 2). This phase readily suggests that the damage of frostbite is both to superficial tissues and to vascular channels in the affected area. It appeared that the rapidity of

edema formation paralleled the rate of thawing. Sections taken immediately after the cessation of thawing in treated animals revealed essentially no change in the epidermis. The subcutaneous tissues showed hyperemia of the vessels, severe hemorrhage into the tissues, necrosis of muscle, and a minimal cellular infiltrate of lymphocytes and polymorphonuclear leukocytes. The edema was severe and accompanied by vesicle formation. The vascular walls showed essentially no morphologic change. No thrombosis occurred at this time. No changes were noted about the nerves present. Although the treated animal did not cry with pain when fully awake, nevertheless it did almost no walking about the cage. Its appetite was poor, and weight loss was the rule. The animal allowed to thaw at room temperature, on the other hand, was able to

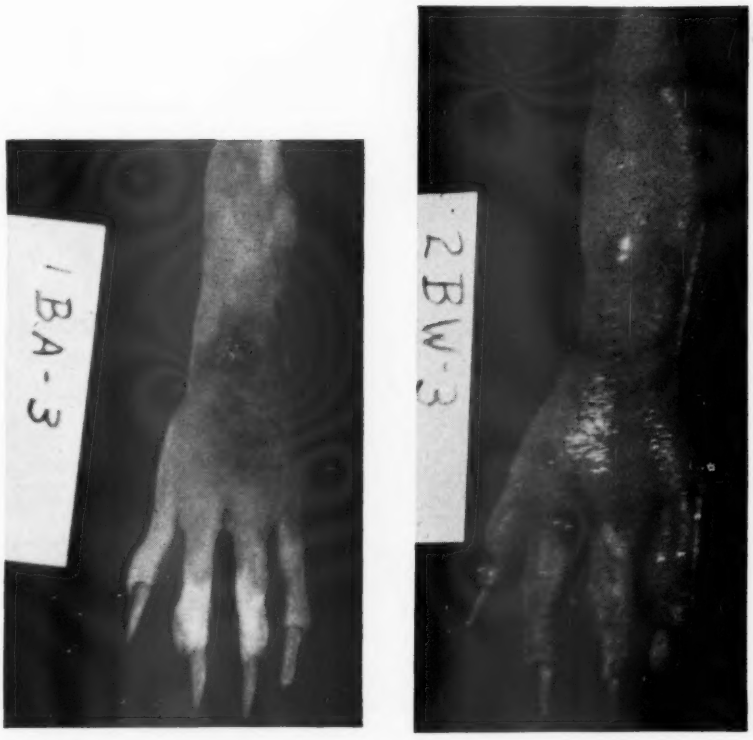


A. *B.*

Fig. 3.—*A*, Extremity of a treated animal immediately after being subjected to thirty minutes of rapid thawing at body temperature. There are massive edema and early bleb formation. The separation of the digits is due to the marked edema present.

B, A close-up of Fig. 3, *A*. Note the early large bleb formation. The darkened areas represent areas of petechial hemorrhage into the subcutaneous tissues.

get about the cage without too much difficulty and apparently did not suffer from pain. The appetites of control animals were diminished, but not to the degree seen in the treated animals. Within the next twenty-four hours, blebs and fissuring (Fig. 3, *A* and *B*) with weeping appeared in both treated and untreated rabbits, but were more exaggerated in the animals subjected to rapid thawing. In fifty hours (Fig. 4) edema in both treated and control animals began to subside, and areas of dry gangrene replaced the wet gangrene of the treated animals (Fig. 5). In six to eight days (Fig. 6, *A*, *B*, and *C*) the control animals exhibited scattered areas of dry gangrene, and the treated animals

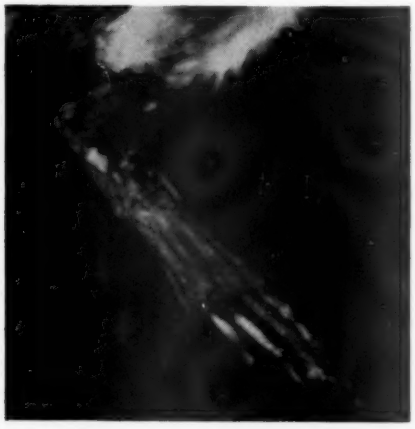


A. *B.*

Fig. 4.—*A*, Control animal showing some edema three hours after exposure to freezing. *B*, Treated animal three hours after rapid thawing. The edema has continued to progress. There has been a fusion of the petechiae into a diffuse, hemorrhagic pattern at this time.

Fig. 5.—The control animal at fifty hours. There are scattered areas of dry gangrene present. At the termination of the experiment after freezing, only these areas have been destroyed by gangrene.

a mummified, dry, gangrenous extremity. Mummification involved only the previously frozen area, which was separated from normal tissue by a sharp line of demarcation. The frostbite as produced led to gangrene which was fully as severe in the treated animals. Indeed, in the treated animals the gangrene was wet and accompanied by more edema and evidence of pain.



A.

B *C.*

Fig. 6.—*A*, *B*, and *C*, Photographs of several of the treated animals at the termination of the experiments in six to eight days. There is now a completely dead, mummified, dry, gangrenous extermity. The line of demarcation is clear cut. There was no evidence of any infection at this time.

DISCUSSION

Three points of view have been promulgated in modern medical literature relative to the efficacy of rapid thawing in the treatment of the acute stages of frostbite:

1. Rapid thawing is of therapeutic value (Röden,[5] Crismon and Fuhrman,[6] Arev,[7] Shumacker[8]).

2. Evidence for the efficacy of rapid thawing is equivocal (Harkins and Harmon,[9] Edwards and Leeper[10]).

3. Rapid thawing is of no value or is detrimental (Theis,[11] Schneider,[12] Lange, Wiener, and Boyd[13]).

The first view appears to be the most widely accepted at the present time and, we believe, wrongly so. While much fine experimental work has been carried out on the subject of rapid thawing in frostbite, experimental conditions have varied so widely that the studies do not allow valid comparison. Possibly the greatest cause for the variable results reported in these experiments has been lack of control of time, temperature, and mass, as shown by Allen and Safford.[14]

The animal most commonly studied has been the rabbit. The hind limb in this species offers a relatively constant mass. One cannot compare the end result obtained in treating frostbites of the hind limb of the rabbit with frostbite of the ears of this animal, much less with the tails of rats or the limbs of dogs in so far as mass is concerned. Unfortunately, mass has been entirely disregarded in comparing the results of various experiments.

Pichotka[15] has shown that there is a critical point of time (of exposure)-temperature relationship to produce a standard lesion. While this lesion is relatively severe, it closely simulates many cases of frostbite in man and constitutes the only alternative to a variable lesion which would invalidate control studies in the laboratory.

To produce a standard frostbite lesion, attention must be given to this critical point in temperature and in its relation to length of exposure, that is, "time-temperature" or "degree minutes." Therefore, in comparing the results of various excellent experiments, even in the same anatomic area of the same species, we must be able to deal with a lesion comparable as to degree of freezing in terms of temperature and length of exposure. Without such standardization, investigators may not be discussing the same lesion. Obviously, the effect of various therapeutic agents would, under such circumstances, vary.

In the case of our own observations, based on a standard freezing injury in the species selected (the rabbit), no variance with clinical observations in man has been brought to our attention. We, of course, realize that the results of all animal experiments on frostbite must be interpreted with caution in planning therapy in a different species such as man. However, our studies give no experimental support to the use of rapid thawing in the treatment of frostbite in man, although our thawing time is prolonged.

It is, of course, obvious that many cold injuries in man such as were seen in Army personnel in Korea cannot be diagnosed accurately in so far as differentiating between true freezing and "immersion foot." We are in agreement with Shumacker that actual freezing is not necessary for cold injury to occur, but in our experiments actual freezing in the absence of wetting agents (true

frostbite) was produced. Our observations and conclusions, then, are based on frostbite due to freezing, and while the conditions of the experiments closely parallel those under which man is frequently threatened by exposure to cold, our results may not apply to other forms of cold injury. As has been mentioned, however, unless seen very early it is not always possible to differentiate true frostbite from other cold injuries.

Under the conditions of our experiment, rapid, thorough warming of frostbitten areas was of no value in preventing loss of tissue as compared to tissue loss in control animals warmed at room temperature. Indeed, the lesion appeared to be made more severe, in that edema was more marked in the early stages of treatment, and pain appeared to be more severe.

We believe that in the acute stage of severe experimental frostbite, rapid thawing, sympathetic blocks, and anticoagulants are of no value. This is not surprising if one realizes the similarity of abnormal physiologic processes induced by all thermal injuries, whether induced by cold or heat. It seems clear, for example, that lymph flow and vascular clotting in areas injured by either heat or cold are essentially similar (Cope,[16] Langohr,[17] Blain[18]). One would not expect anticoagulants, rapid thawing, or rapid cooling, sympathetic blockade, or vasodilators to be of much efficacy in the treatment of burns.

CONCLUSIONS

1. In fifteen rabbits with acute, severe frostbite, rapid, thorough thawing at body temperature did not reduce tissue loss as compared to the amount of tissue lost in fifteen untreated control rabbits.

2. Rapid, thorough thawing appeared to increase the severity of tissue damage, edema, pain, and gangrene.

3. It would appear that the present confusion regarding the efficacy of rapid thawing in the treatment of frostbite is partly due to study of experimental lesions which are not comparable.

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COMPREHENSIVE SURGICAL MANAGEMENT OF CAVERNOUS HEMANGIOMA OF THE LOWER EXTREMITY WITH SPECIAL REFERENCE TO STRIPPING

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IN THIS paper, which is restricted to congenital cavernous hemangiomas of the lower extremity, we shall discuss the important points in diagnosis and present the findings in a series of nineteen cases (twenty extremities). Also we shall classify and discuss the common anatomic patterns. Most emphasis, however, will be placed on management, which includes removal of the involved veins by stripping and direct dissection along with ligation of perforating veins.

In reviewing the literature we have been unable to find an author who recommends stripping as the treatment of choice. De Takats[1] in 1932 reported three cases in which the lower extremity was involved and in which he advocated early radical excision with special emphasis on eliminating the "feeding vessel." The surgical procedure was followed by obliterating injections. For many years, Homans[2] has advocated low-high division of these venous anomalies followed by sclerosing therapy.

In this report we shall emphasize early radical excision by the stripping technique followed by sclerosing therapy. But in our experience there is no one "feeding vessel" but a very extensive venous system which has definite and different patterns. These patterns are associated closely and are kept active through multiple feeding vessels, the perforating veins (perforators), which make the deep and superficial veins closely allied. At no time during the extensive exposure at operation, nor in the arteriogram or venogram, was there gross evidence of arteriovenous fistula in this series of cases.

Even though we did not prove or disprove that some of the patients in our series had minute arteriovenous fistulas, it is our impression that the problem is mainly a venous one, and that if the abnormal veins and perforators are eliminated, the usual complications will be altered or eliminated. So far, we cannot see that patients with increased length of extremity (usually thought of as the group with congenital arteriovenous fistula) constitute a different problem so far as control of the veins is concerned. In our series of twenty extremities, five had increased length of the fibula and tibia. (In addition, we have encountered one case, not included in this series, in which there was increased length of the femur only.) While we have no definite proof that venous stasis causes increased length of extremity, we think that such a possibility should be entertained. In this connection, Lacroix[3] has said that the

Read at the eighth annual meeting of the Society for Vascular Surgery, San Francisco, June 20, 1954.

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only influence of a vascular nature which appears to affect osteogenesis is venous stasis. Servelle[4] in 1945 observed two clinical cases in which a certain excess elongation of bones in a leg was associated with the existence of an obstacle to the return circulation from the limb. It should be added that regardless of the cause of the increased length of bone, stapling of the epiphyses above and below the knee may be resorted to in an effort to equalize the length of the extremities, as recommended by Blount and Zeier.[5] For example, in one of the patients not in our series such stapling was carried out, with the result that during a subsequent four-year period the discrepancy in length of the extremities was reduced from one and one-half inches to one-half inch.

DIAGNOSTIC CONSIDERATIONS

Symptoms and Signs.—The history usually states that a port-wine stain or dilated veins or both were first noted at birth or shortly afterward. In many instances this condition is not viewed with alarm by either the family or the physician. However, in some patients, even early in life, the veins become large and tortuous and cause congestion; our youngest surgical patient was 18 months old. Usually, however, the patient is 8 or 9 years old before the condition becomes serious enough to cause the home physician to seek consultation.

If the patient is not treated early, usually the most troublesome symptom is congestive pain in the lower part of the leg or about the knee. This is variable in degree; in our series of nineteen patients, all complained of mild to severe congestive pain when they stood erect. Several of the younger patients with severe congestive pain would raise the involved extremity and place the foot on the opposite knee, resting it there when standing, to help relieve the pain. One 9-year-old child actually had so much blood shunted from the general circulation into the large veins of the lower extremity that she felt dizzy for a short time after she stood erect. This condition was relieved by surgical treatment.

Seventeen patients gave a history of edema, grade 1 to grade 3 (on a basis of 1 to 4). Two gave a history of stasis ulcer, which was confirmed by the presence of residual scarring. Three gave a history of chronic induration, which was confirmed by examination. Parenthetically, it is pointed out here that walking venous-pressure readings in patients with cavernous hemangioma are similar to those in patients with insufficiency of the deep veins resulting from deep thrombophlebitis, and usually the readings are not altered by removal of the superficial veins. However, removal of such veins has a very beneficial effect on the type of local congestion in the tissue surrounding the superficial veins.

The diagnosis of cavernous hemangioma is obvious on inspection (Fig. 1). The lower extremity is enlarged and is covered with large tortuous veins. As a general rule, an extensive port-wine stain is present (in nineteen of twenty extremities in our series). There is usually dependent (orthostatic) edema of the ankle (seventeen of twenty extremities); this is related to congestion or,

occasionally, to the simultaneous presence of a lymphangioma (two of twenty extremities). The latter condition gives a more diffuse, symmetric enlargement of the foot, leg, and thigh, so that surgical treatment of the veins alone will not give a good cosmetic result; the condition can be very extensive. In one of our cases an amber fluid ran from the incisions in the leg, but the abnormality did not cause delayed healing of the wound. In this case large sinuses filled with lymph were visible subcutaneously. So far, this patient has been treated satisfactorily by an elastic support, but eventually it may be necessary to resort to a Homans operation.

Fig. 1.—*a* and *b*, Bilateral lumbar-to-foot pattern combined with a short saphenous pattern on the right.

In our series there were only five extremities in which the length of the bone was increased. This increase was in the fibula and tibia, which apparently are the usual sites of occurrence. The increased length was associated with the lumbar-to-foot pattern in three cases, with the short saphenous pattern in one case and with the long saphenous pattern in one case. This certainly suggests that there is no specific influence on the bone by a particular venous pattern. It was found, in addition, that in all five extremities in which the length of bone was increased the circumference of the extremity also was increased.

In all but three of the twenty extremities there was increase in the circumference of the thigh and leg. In the cases in which the extremities were smaller than normal there was definite decrease in muscle development. In two of three cases the foot was underdeveloped, and this was attributable to

actual shortening of the bones. As mentioned previously, in the cases in which the length of the extremity was increased, the increase appeared to be due to lengthening of the fibula and tibia. From a clinical point of view we assumed that these patients had congenital arteriovenous fistula, although at no time have we been able to demonstrate such a fistula by arteriographic studies. The results of oxygen-saturation studies do not always seem to be consistent with this idea. Recently we have been taking all specimens for oxygen-saturation studies by direct exposure of the femoral veins, so that there would be no doubt as to the source of blood, and the oxygen saturation has been the same even though one extremity was longer than the other. On the contrary, in several cases in which there was no increased length of the extremity the oxygen saturation has been lower in the femoral vein of the extremity with the hemangioma. Obviously there is need for further study along this line.

The incidence of certain signs and symptoms in our series of cases is given in Table I.

TABLE I. SIGNIFICANT SIGNS AND SYMPTOMS IN CAVERNOUS HEMANGIOMA OF THE LOWER EXTREMITY (TWENTY EXTREMITIES)

SYMPTOM OR SIGN	EXTREMITIES
Congestive pain	20
Port-wine stain	19
Stasis changes	7
Increased length of extremity*	5
Lymphangioma	2

*Increase attributable solely to increased length of the fibula and tibia.

Venous Patterns.—It is important to distinguish the venous patterns so that an intelligent surgical approach can be made. Four distinct patterns are definitely ascertainable but any one pattern may vary enough to involve veins in other patterns.

1. The most frequent pattern is the lumbar-to-foot pattern (Fig. 2). This was the pattern in eleven of the twenty extremities in our series. This pattern, in its fullest extent, involves veins from the lumbar region to the toes. However, in some of the cases, even though the port-wine stain is located in the lumbar-hip region, the large veins end in sizable perforators on the extreme upper end of the lateral aspect of the thigh. Occasionally the veins do not extend into the foot, but cease to be very large at the juncture of the middle and distal thirds of the leg. There are always large veins above and below the knee. Whenever large veins are present, they are associated with large perforating veins. Whenever there are large veins in the foot, there usually are large perforators about the ankle and dorsum of the foot.

There are two main variations of this pattern in its advanced form. In the first, the lower end of the long saphenous vein is dilated by association with large branches coming from the lateral thigh vein which cross over just above and below the knee (Fig. 2, *a*). In this variation the long saphenous is not incompetent in the medial part of the thigh from the region just above the knee to the saphenofemoral juncture. In the second variation there is incompetency of the short saphenous vein (in three of eleven cases of our series). When the

short saphenous is also involved, it usually is a very important, large dilated vein which always is associated with large dilated veins on the lateral side of the foot; the latter veins extend into the fifth to second toes, inclusive. Usually perforators are present on the lateral side of the foot. Through communicating veins there is always a close association between the large short saphenous and the main veins coming down from the thigh.

Another characteristic in the lumbar-to-foot pattern, which is rarely associated with ordinary primary varicose veins, is that the veins in the lower half of the extremity usually are larger than those in the upper part of the thigh, a characteristic that is more pronounced in patients who have a large number of perforators.

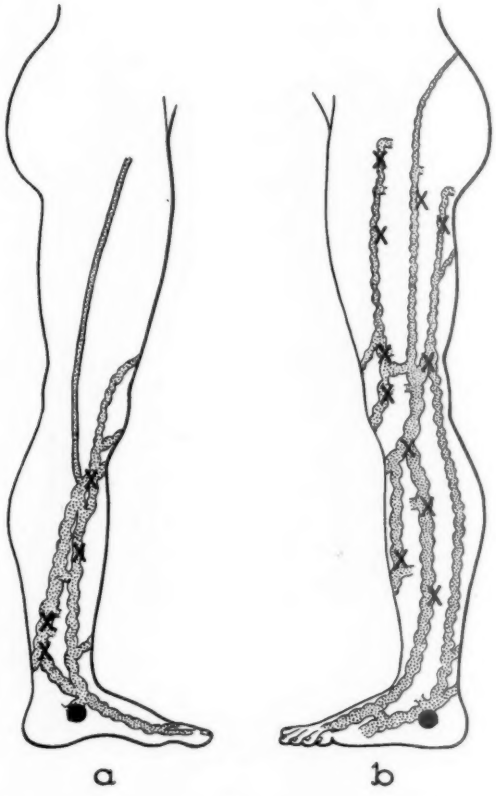

Fig. 2.—Typical advanced lumbar-to-foot pattern. The *X*'s represent the approximate sites of the perforating veins and the dots represent common perforating veins of the foot. *a*, Medial surface showing a normal saphenous vein in the thigh and large incompetent channels below the knee associated with perforating veins. *b*, Lateral view showing main channels.

2. The second pattern is the long saphenous pattern. It occurred in seven of the twenty extremities in our series. This may appear as an ordinary incompetent long saphenous vein associated with port-wine stain. There may also be involvement of the skin around the knee, or the port-wine stain and the enlargement of veins may extend from the lumbar region down over the hip and into the front part of the thigh, involving the main channel and tributaries of the long saphenous system. The veins are not large in the lumbar

and hip regions, but become very large and incompetent throughout the long saphenous system. Perforators again are important in this pattern. The patient represented in Fig. 3 had fourteen large perforators.

3. The third pattern is the gluteal-short saphenous pattern, which originates with extremely ballooned-out veins in the gluteal region (Fig. 4). In the only case in our series the short saphenous was also an intricate part of the pattern, there being extensive connecting veins in the posterior part of the thigh.

4. The fourth pattern is simply that of an incompetent short saphenous vein with perforators on the lateral side of the foot, associated in our only case with a definitely lengthened fibula and tibia. The thigh and gluteal regions and the long saphenous vein are not involved.

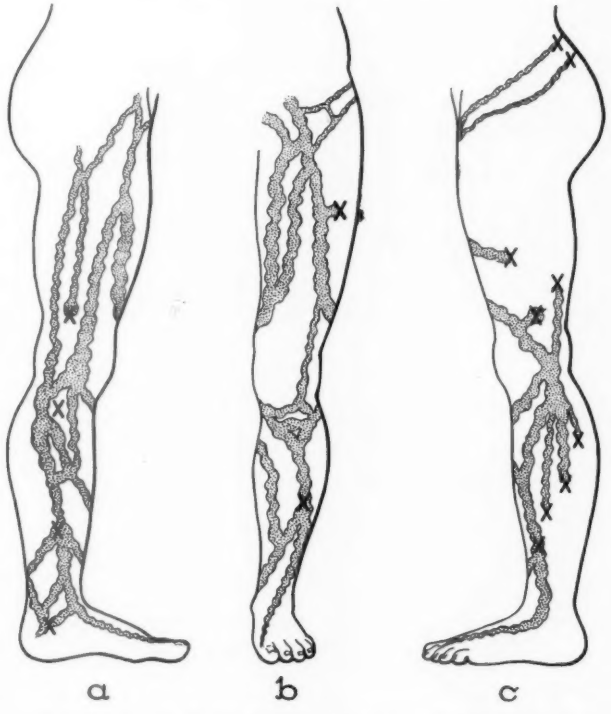

Fig. 3.—Long saphenous pattern. *a*, *b*, and *c*, Medial, front, and lateral aspects of the extremity, respectively.

The distribution of the extremities in our series of cases according to venous pattern and side involved is shown in Table II.

Venography.—Venograms are of interest in these cases. In our earlier studies they enabled us to obtain a better idea of the extensiveness of the venous pattern, but they offered us very little specific diagnostic information. After considerable experience we decided that venography is not necessary for evaluation of a patient for surgical treatment. The venous pattern can be determined readily by physical examination with the patient standing erect. The perforators are best located by palpating for the vein as it goes through a defect in the deep fascia. Our first plan was to determine the status of the

deep veins by venography but we found it difficult to get the dye into these veins when it was injected into the superficial ones. The dye usually enters the deep veins only if the leg is put in a dependent position. Even then, with the superficial and deep veins both filled with dye, it is doubtful if an accurate reading can be obtained.

TABLE II. DISTRIBUTION OF CASES OF CAVERNOUS HEMANGIOMA OF THE LOWER EXTREMITY ACCORDING TO VENOUS PATTERN AND EXTREMITY AFFECTED (TWENTY EXTREMITIES)

VENOUS PATTERN	RIGHT	LEFT	TOTAL
Lumbar-to-foot	4	7	11*
Long saphenous	4	3	7
Gluteal-short saphenous	1		1
Short saphenous		1	1
Total	9	11	20

*The short saphenous vein also was involved in three of these extremities.

Even though the deep veins seem to be functioning below normal in many of these patients and apparently cannot compensate enough to prevent edema in most of them, there is rarely an absence of deep veins. Clinically, it is obvious that there is a deep system of veins because of the presence of multiple perforating veins. However, one should always be on guard against the possibility that the deep system may not function adequately, as illustrated in one of our cases. In this case, after exploration of the deep veins at the saphenofemoral juncture, which appeared normal, the saphenous vein was separated at the groin. As a result, very severe congestion of the whole saphenous system developed. The greater saphenous vein continued to be congested even with high elevation of the extremity, which certainly gave the impression that the deep system of veins was inadequate or that the superficial and deep veins were not connected by perforators. Under these circumstances it seemed wise not to strip the superficial veins. The patient was not helped by the ligation and it took several months for the extreme congestion of the saphenous system to subside. There is still some increase of congestion in the extremity, although this is not severe. As a result of this experience, we always make a preliminary test of the emptying of the hemangioma by elevation of the extremity after a tourniquet has been placed high around the thigh. We have not yet found a similar case.

Perforating Veins.—Although perforating veins were found in nineteen extremities of our series, they constituted a much more important part of the pattern in the more advanced and difficult case. Such veins present practically an impossible obstacle in an area which has become so honeycombed that there are hundreds of connections between the deep and superficial veins. This condition was encountered in only one of the extremities of our series and the operation could not be completed. Several other patients, however, who were not included in this series, were refused operation because this condition was recognized preoperatively.

The extensiveness of perforators that can be handled surgically is shown in Figs. 2 and 3. As mentioned previously, it is necessary to ligate all per-

forators behind the fascia and to close the fascia if possible. A typical large perforator is shown in Fig. 5.

Enlarged veins in the feet can be very destructive, causing atrophy by pressure upon the surrounding soft tissue. This is especially true if the veins

Fig. 4.—Infrared photograph showing the gluteal-short saphenous pattern.

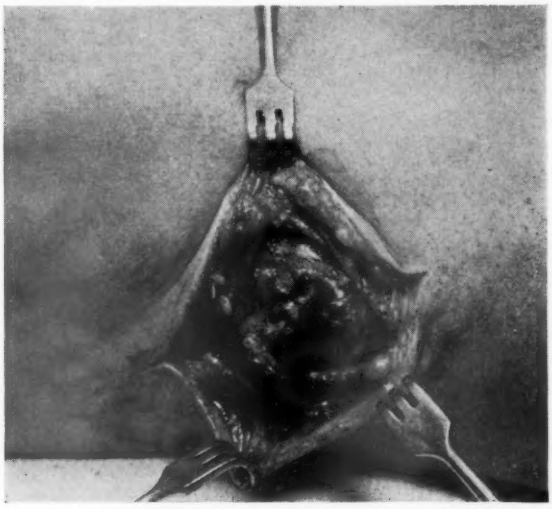

Fig. 5.—Typical large perforating vein.

are in the deep tissue of the foot. In one case in this series the patient had several toes which resembled little balloons when she stood erect. These were helped by sclerosing therapy. In another case, but not included in this series, the patient had so much atrophy of the toes and foot when the veins were emptied by elevation that the skin lay on top of the bones in such a way as to give the appearance of mummification. In this case the condition was too far advanced for treatment. It is apparent that such dilated veins should be removed before extensive changes can occur.

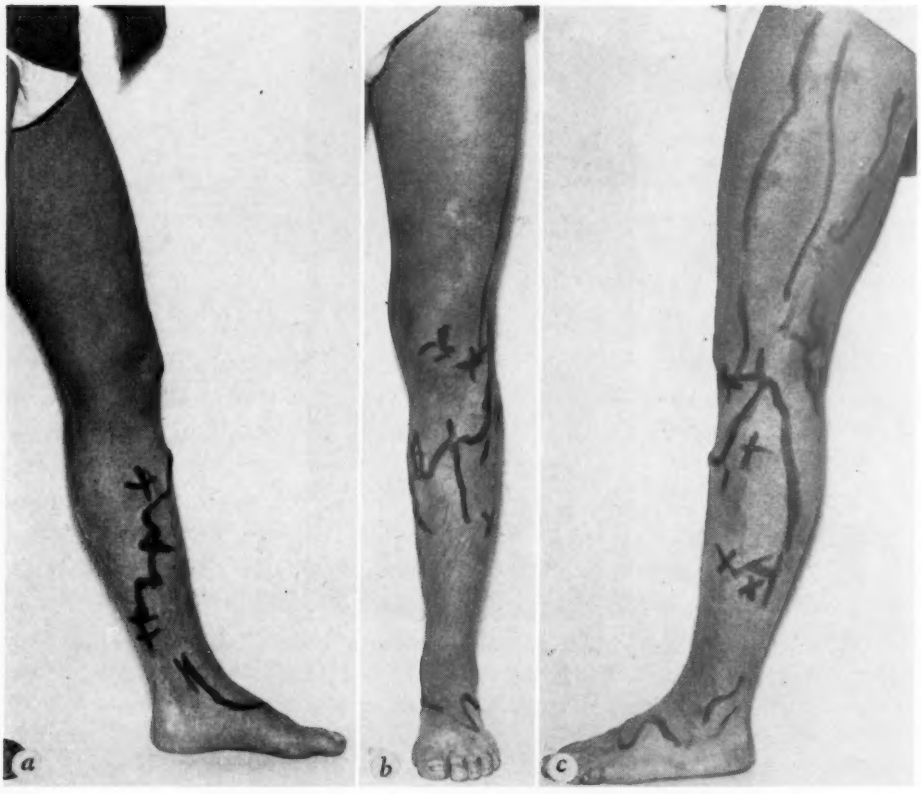

Fig. 6.—*a*, *b*, and *c*, The main channels to be removed have been indicated by the marks on the skin.

PREOPERATIVE PREPARATION

It is our practice to re-examine our patients the day before operation. By this time we have done a complete physical examination and the patient has been declared suitable for general anesthesia. It is preferable that the value for hemoglobin be at least 11 Gm. per 100 c.c. of blood. We also plan to have 1,000 c.c. of typed and cross-matched whole blood available in case we need it. We have had to transfuse five patients of this series during operation. If arteriography was planned, it will have been performed before operation, but most of the time such a study is not made because it has not proved helpful in adding to our knowledge of congenital arteriovenous fistula in these cases.

Venography also will have been carried out if planned, but in recent years we have stopped use of this procedure also, because it has not added valuable data as to the forms of treatment necessary.

The most important accomplishment at this examination is a plan for the operation. All veins to be removed are marked[6] while the patient is standing erect, and the perforators are located by palpation of the defect in the deep fascia and an "X" is placed where an incision is to be made (Fig. 6).

After the patient is admitted to the hospital, the hair of the appropriate area is removed by shaving. No other preliminary preparation of the skin is considered necessary.

SURGICAL TECHNIQUE

The patient is given the appropriate premedication intravenously in the operating room. He is anesthetized with thiopental (Pentothal) sodium given intravenously and is intubated.[7] Intubation is usually advisable because the patient has so many veins on the lateral and posterior surface of the thigh and leg that he will have to be turned on his side or to a prone position to obtain proper exposure; hence, with intubation, anesthesia and oxygen exchange are assured in any position. As a rule, the patient is also given ½ to 1 ounce of ether through the anesthesia machine. This permits a much longer anesthesia without large doses of thiopental.

The patient's skin is prepared, as in all operations, with soap, water, alcohol, ether, and an antiseptic solution (tincture of Merthiolate). An orthopedic drape is made so that the patient will be ready for an incision anywhere in the lower extremity, buttock, or lumbar region.

In all cases the extremities are left in a horizontal position and the operation is begun by making an incision at the base of the toes. The distal veins are tied and the large proximal veins going over the foot are followed upward. All abnormal veins in the feet are tied and all marked perforator sites in the foot are exposed and the perforators ligated behind the fascia. In the case of the lumbar-to-foot pattern, the flexible intraluminal strippers of variable sizes and lengths can be used to locate all channels (Fig. 7). Usually these can be passed upward through the main channels very easily because the channels are fairly straight and dilated.

Many times the stripper will go the full length of the leg and thigh to the large perforating vein or veins on the lateral surface of the upper part of the thigh. Several strippers can be placed from any direction feasible. Then all perforators should be tied in the thigh and leg before the veins are removed by stripping. All sizable tributaries should be noted with the idea of passing a stripper into them for removal. The ideal is to remove all the dilated superficial veins involved in the pattern—it is almost unbelievable the number of veins that can be removed in the extensive case. During the process of pulling the strippers, the surgeon should watch for unusual bleeding because that means a tributary is remaining open or a perforator has been torn. We usually tie the veins to the stripper with silk fish line and pull the silk thread

along behind the stripper so as to have the channel well marked; this permits checking for bleeding and makes it easy to put in temporary packing until the bleeding point can be located.

When the short saphenous vein is involved in the lumbar-to-foot pattern, the stripper can be passed from the base of the lateral toes to the saphenopopliteal juncture. Care must be used to locate all tributaries connecting the veins from the lateral regions of the leg and thigh with the short saphenous vein, so that they can be removed.

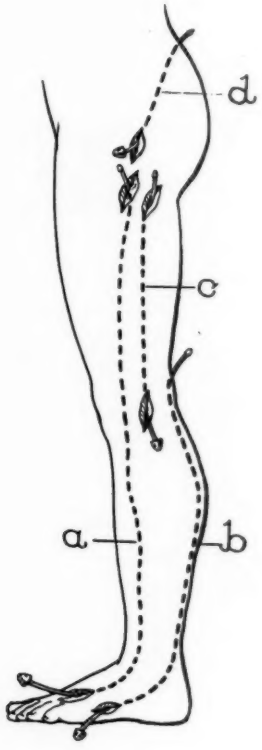

Fig. 7.

Fig. 8.

Fig. 7.—*a*, Stripper extending from the base of the toes to the common perforating vein in the upper part of the thigh. *b*, Stripper extending from the base of the toes through the short saphenous vein. *c*, Removal of tributary in the thigh. *d*, Removal of vein from the upper part of the thigh to the lumbar region.

Fig. 8.—The usual technique for removal of the long saphenous vein.

When the veins of the long saphenous pattern are to be removed, the operation is quite similar to that used upon a primary varicosity, but generally it is a much more extensive procedure because of the wide distribution of the vein with many more large perforators (Fig. 8). In these cases intubation is usually not necessary, since the rotation of the patient is not called for. The veins from the groin to the lumbar region may be too small to accept a stripper but they should be removed if possible. In these cases the patient may have to be rotated, in which event intubation may be necessary.

The gluteal-short saphenous pattern presents a real problem so far as the gluteal region is concerned. These veins are extremely cavernous and widely

distributed, and apparently are in close association with large veins deep in the region of the buttock. In many of these patients the buttock is spongelike and presents practically an impossible surgical situation. The veins connecting the short saphenous and the gluteal regions can be removed by stripping (Fig. 7, *b*)—this should be done. The short saphenous can be removed by stripping, with special attention being given to likely perforators on the lateral side of the foot.

The short saphenous pattern, when alone, can be handled as described previously. It offers no more difficulty than does the usual primary varicosity.

The distribution of the extremities in our series according to surgical procedure used is shown in Table III.

Fig. 9.—Typical postoperative appearance of the extremity of a patient with a lumbar-to-foot pattern.

After the stripping has been finished in these operations, the bleeding should be under control while the patient's legs are still horizontal. However, there may be general oozing from some of the wounds made through scarred areas. It is usually advisable to have the foot of the operating table elevated approximately forty degrees while the wounds are being closed. The wounds are approximated with interrupted vertical mattress silk sutures. The sterile dressing may be held in place with Elastoplast tape or wrapped on with a goiter roller bandage. All wounds should be supported with padding and 4-inch elastic bandage, two or three of the latter being used for each extrem-

ity. Postoperatively the extremity is kept elevated at a thirty-degree angle at all times except, of course, when the patient is walking. Ambulation must be kept to a minimum to prevent edema; perhaps two minutes out of each hour may be permitted at first, starting on the second postoperative day. The typical postoperative appearance of the extremity of a patient with the lumbar-to-foot pattern is shown in Fig. 9.

TABLE III. OPERATIONS ON TWENTY EXTREMITIES OF NINETEEN PATIENTS WITH CAVERNOUS HEMANGIOMA OF THE LOWER EXTREMITY

OPERATION	EXTREMITIES
Stripping	16
Multiple ligations	2
Exploratory operation: further operation not feasible	2
Multiple perforating veins ligated	18

AFTERCARE

The patient is given the usual postoperative care after the stripping operation. Many of the patients do much better if they wear elastic support indefinitely. An elastic stocking may be enough, but we usually recommend an elastic wrap-around bandage.

These patients respond well to injection of the spider-burst type of veins. It is also our practice to inject veins that cannot be removed at operation; however, such injection treatment should be minimal. Each patient is seen four to six months after operation and injections are given if necessary. Then, as a rule, they are seen yearly.

RESULTS IN TWENTY EXTREMITIES

All nineteen patients in this series are in satisfactory condition except two whose condition proved to be inoperable and one, a woman, who underwent stripping only to the mid-leg region. The last-mentioned patient had been operated on early in our experience with stripping (1949) and had continued to have progressive induration along the course of the vein in the lower part of the leg; hence, recently (1954) removal of the vein in the lateral surface of the leg was finished and two large perforators were tied.

All ten patients who had severe congestive pain preoperatively obtained marked relief; however, this is hard to explain because the walking venous pressure at the ankle is not altered to any degree in many of these cases. The elastic support, of course, helps considerably, but removal of the large heavy superficial veins and perforators is extremely important in relieving congestion, stopping stasis changes, stopping destruction of skin and soft tissue, and giving a better cosmetic appearance.

The one patient who had dizziness when she stood erect was relieved of this when the extremely large superficial veins were removed.

CONCLUSION

We believe that extensive surgical treatment such as that outlined here, followed by frequent follow-up examinations and sclerosing therapy, may have

much to offer patients with cavernous hemangioma of the lower extremity. However, as yet our follow-up period has not been long enough and our number of cases has not been large enough to permit adequate appraisal of this plan of treatment. The plan does seem to offer much better control of the condition than do other plans currently available. We intend to operate on future patients as early as possible, and see whether we can alter the course of the disease enough to prevent the common complications and sequelae.

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THE EVALUATION OF A METHOD OF PHLEBOGRAPHY OF THE LOWER EXTREMITIES

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THE first phlebographic studies, by Frank and Alwens[1] in animals and Beberich and Hirsch[2] in human beings, utilized the physiologic direction of venous blood flow to transport the contrast medium. Since then, many workers in this field have added modifications to improve the usefulness of this type of procedure.[3-7] In 1950 one of us[8] presented a phlebographic technique with the patient placed at fifteen degrees from the horizontal. An analysis of percentage of visualization with this method was given. Later Scott and Roach[9] reported a modification with the patient at seventy-five degrees from the horizontal. The latter authors made no critical analysis of their results. In 1952[10] and more recently[11-13] one of us presented a similar study with the patient at sixty-five degrees from the horizontal. These previous studies have all shown low visualization percentages. The present study was undertaken to improve the visualization.

METHOD

The patient is placed on an x-ray table in the horizontal position, dressed in a cotton hospital gown. All elastic wrappings are removed from the legs, and gum rubber tourniquets are placed tightly around the ankle. Some patients have complained of pain with this procedure; however, the short length of time needed for the study does not make this complaint a serious deterrent. An intravenous infusion of 200 ml. of either 5 per cent dextrose or saline solution is started in a small vein on the dorsum of each foot with a No. 20 or No. 22 needle. An adapter from each infusion needle is attached to eighteen inches of rubber tubing which runs to a glass Y adapter. From the Y another short piece of rubber tubing is attached which will fit over the needle adapter of the intravenous set (Fig. 1).

Once the needles in the vein are well secured with tape, the patient, table, and x-ray tube are tilted, to a sixty-five degree angle from the horizontal. The legs are internally rotated as far as possible to separate the tibia and fibula projections on the film, and a two-inch diameter sandbag is placed under the patient's heels. This raises the heel approximately one and one-half inches above the toes. The x-ray tube and film cassette are placed to include the leg from the heel to the knee on the initial film with the tube in the first stereo position, one and one-half inches from the center.

A syringe containing 20 ml. of 35 per cent Diodrast (iodopyracit USP*) is then attached to the rubber tubing above the glass Y. A hemostat is clamped

Read at the eighth annual meeting of the Society for Vascular Surgery, San Francisco, June 20, 1954.

*Winthrop-Stearns, Inc.

on one of the tubes from the glass Y to the foot and the 20 ml. of Diodrast injected as rapidly as possible, but without excessive force. The hemostat is then released and clamped on the tube to the opposite foot, and a second syringe of

Fig. 1.—The patient in position for phlebography with the table tilted to a sixty-five degree angle. The intravenous fluid container is placed above the heart level.

20 ml. of Diodrast injected. The hemostat is again shifted and 20 ml. more is injected into the first foot, and then again into the second foot. This makes a total of 40 ml. of Diodrast injected into each, or 80 ml. of Diodrast in all. The

intravenous set is then reconnected to the glass Y and opened to run at a rapid rate. The fluid container must be placed at a level above the heart to allow a rapid rate of infusion into the veins of the feet.

The films are exposed ninety seconds after the completion of the injection, making two stereo exposures of the legs. The cassette and x-ray tube are then moved and one exposure made of the thighs. The exposures should be made in as rapid succession as possible (not over thirty to forty-five seconds). It may take some practice to familiarize the x-ray technicians with the procedure.

After this the patient is lowered to the horizontal position. The rubber tourniquets are removed and the rate of infusion reduced. The needles are left in place until the films are developed to assure that a repeat study is not needed. The x-ray exposure technique should be that which shows bony trabeculations of the proximal head of the tibia. Variations of thigh size and leg edema must be corrected for in the exposure. We have used 14 by 17 inch films for our study and have found that bilateral studies are of value for interpretation.

In a few instances it has been necessary to hospitalize the patient for twenty-four hours with elevation of the feet, and complete bed rest, to reduce the dependent edema. In no instances in our series was a surgical incannulation necessary. The greater saphenous vein just below the ankle may be used for the infusion if care is taken to compress it above the needle with the tourniquet.

RESULTS

Eighty-four phlebographic studies were made by the technique described. The ages of the patients varied between 17 and 72 years, with an average age of 53 years. The indication for the study was the presence of a postphlebitic syndrome which did not respond to conservative treatment. All limbs except one had either a leg ulcer or advanced stasis changes in the skin. No instance of active thrombophlebitis was included.

TABLE I. PERCENTAGE OF VISUALIZATION. COMPARISON OF THE PERCENTAGE OF VISUALIZATION BETWEEN EARLIER STUDIES USING 40 ML. OF CONTRAST AGENT[13] AND THIS REPORT USING 80 ML., IN THE POSTPHLEBITIC LIMB

VEIN	1952	1954
Femoral	80.9	85
Deep femoral	15.0	54
Popliteal	83.0	92
Anterior tibial	15.0	84
Posterior tibial	75.3	90
Peroneal	92.3	92
Sural	6.0	84
Thigh communicating		25
Calf communicating lateral		92
Calf communicating posterior		81
Calf communicating medial		89
Long saphenous		65
Short saphenous		23

PERCENTAGE OF VISUALIZATION

Table I gives the percentage of visualization as compared to those reported previously by Felder.[10-13] This technique shows considerable improvement. The greatest improvement is noted in the visualization of the sural, anterior tibial, and deep femoral veins. (Figs. 2-5.)

Fig. 2.

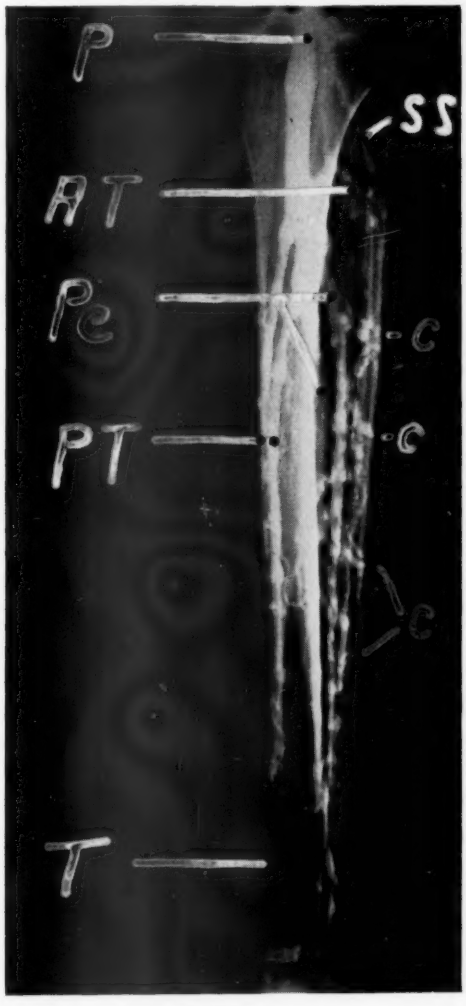

Fig. 3.

Fig. 2.—Normal thigh phlebogram. *F*, Superficial femoral vein with line to a normal valve.

Fig. 3.—A normal phlebogram of the lower extremity. *P*, Popliteal vein; *Pe*, peroneal veins; *PT*, posterior tibial veins; *T*, tourniquet; *AT*, anterior tibial veins; *C*, communicative veins; *SS*, short saphenous vein.

The visualization of the communicating veins of the leg and thigh is important. Felder[10-13] reported these veins as only occasional findings in 1952 (visualization about 11 per cent), while by this technique they are seen in over 80 per cent of the studies. The communicating veins in the thigh, according to Linton,[14] are found in 25 to 30 per cent of anatomic studies. The

visualization of the latter veins in this study correlates with these figures. The long and short saphenous veins are filled in a smaller percentage of cases, but it must be remembered that an attempt is made not to allow these veins to fill, to avoid confusing the "picture."

Fig. 4.

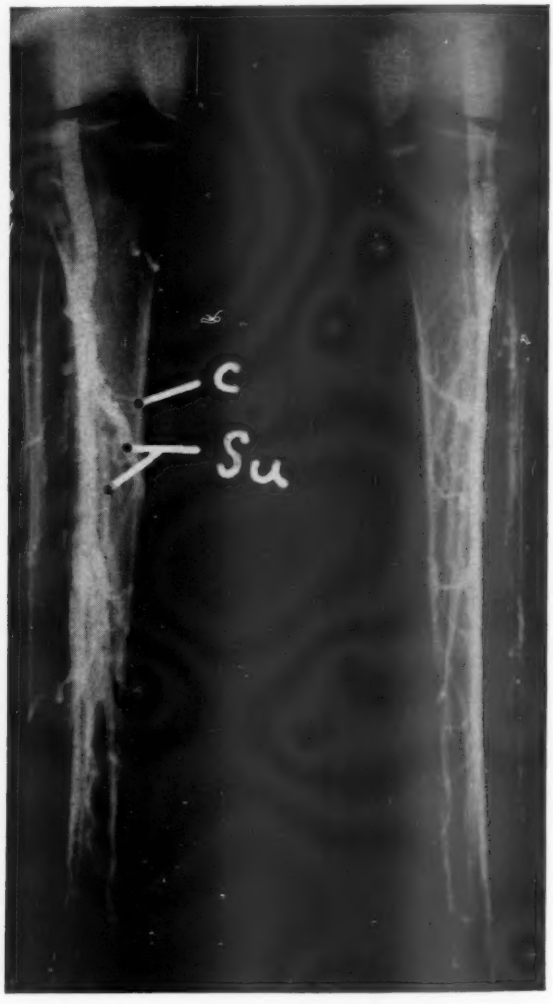

Fig. 5.

Fig. 4.—A thigh phlebogram with many major and minor by-passes via collateral channels.
Fig. 5.—*Su*, Sural veins; *C*, communicating veins.

UNSATISFACTORY PHLEBOGRAMS

There were several instances where faulty x-ray technique caused the films to be discarded, but since the intravenous infusion remained in place, it could be corrected and the procedure repeated. Two extremities studied failed to show deep vein filling of a satisfactory nature at any time.

REACTIONS

1. *Acute Thrombophlebitis* (1.2 per cent).—One patient developed an acute thrombophlebitis ten days after a phlebographic study. This patient gave a history of a postphlebitic limb of ten years' duration with a popliteal ligation three months prior to the study. She had also suffered from repeated attacks of thrombophlebitis during the previous twenty-four months. Whether or not the attack was precipitated by the study may only be speculated upon.

2. *Nausea.*—When the patients are lowered to the horizontal position, they often note a "hot flash" followed by a short period of nausea. These symptoms disappear within sixty to ninety seconds. There were no instances of vomiting.

3. *Pain.*—Other than the discomfort noted in placing the tourniquets and the infusion needles, pain has not been of importance.

4. *Extravasation.*—There were no instances of extravasation of the contrast medium.

5. *Syncope* (1.2 per cent).—One patient, a 24-year-old hyperesthenic woman, experienced syncope during the procedure. However, since it took place toward the end of the study, the films were exposed prior to lowering the head of the table, giving an excellent phlebogram.

INTERPRETATION

The stereoscopic films of the legs allow easy and positive determination of the venous anatomy under consideration. The anatomy of the veins of the thigh is of such a nature as to allow practical interpretation without stereo studies. Sgalitzer[15] described the radiographic findings of incompetent veins in which he noted the "straight line sign" below an incompetent valve; that is, in the picture of a normal valve, the radiopaque medium outlines a curved, inverted V with an outpouching or dilatation above. However, with the incompetent valve, the contrast medium will show a straight radiolucent line across the vein and dilatation below the valve. The following signs, we believe, are important considerations in determining venous incompetency:

1. Exceptional dilatation of the vein.

2. One or more incompetent valves in the same area with dilatation of the vein below the valve.

3. Tortuosity of the vein.

4. Pooling of the contrast medium in deep vein varices.

5. An extensive irregular lumen without visible valve structure.

The finding of one or two incompetent valves need not make an incompetent venous segment; however, when dilatation and/or tortuosity of the vein is added, we may draw such a conclusion. The entire phlebographic picture of the extremity must be taken into consideration in making a final interpretation.

DISCUSSION

The technique presented here is a distinct improvement from that reported in the past. The radiographic interpretation has been made easier by producing a more distinct contrast shadow. This obvious improvement can probably be attributed to the increase in amount of contrast medium in the veins. The higher incidence of sural vein visualization may be due to relative relaxation of the calf musculature with the low sandbag. In the previous studies of Scott and Roach[9] and of Felder[10] the heels were held high either by a wooden block or toweling.

Many authors[16, 17] have stated that phlebographic studies by other techniques are impossible to interpret. Our criticism of the retrograde type study is of that same nature. The use of a hyperbaric contrast agent is known to allow a retrograde flow past a normal valve and furthermore, this technique fills the superficial veins more frequently. We have tried to keep the contrast medium out of the superficial veins so as to not obscure the deep veins. The status of superficial vessels usually may be accurately evaluated on clinical findings alone.

The visualization in this series is still short of 100 per cent. The deep femoral vein is visualized in only 54 per cent of the studies. The popliteal vein is visualized in 92 per cent of the studies; however, most of these failures were due to technical failures of placing the x-ray tube, or "cone cutting." When the technique was changed from using a lateral stereo-shift technique on the legs, to a vertical stereo-shift, this difficulty was eliminated. The popliteal vein was visualized almost 100 per cent of the time in the later studies in this series.

From these studies we feel a very definite practical application may be made. A further understanding and better treatment for the postphlebitic limb should come from a better knowledge of the pathologic anatomy of the disease. We have found a distinct advantage by the use of this technique in evaluating patients for a "flap" operation as described by Linton,[14] and have been able to modify our operation to include areas of incompetent communicating vessels of the lower leg which may normally be missed. We feel that a "flap operation" may not be adequately performed without a phlebographic picture to locate such vessels, and especially their subfascial course. Such films have allowed us to carry out a direct surgical attack at these vessels of the lower leg instead of a blind approach or an approach approximated by the palpable evidence of incompetent communicating veins.

SUMMARY AND CONCLUSION

A technique of iso-flow phlebography has been presented. An analysis by visualization percentages in eighty-four such studies has shown a distinct improvement over previous methods. Furthermore, this technique provides much more distinct films for interpretation. The application of such studies to the technique of a "flap operation" is discussed.

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A NEW TWO-WAY NEEDLE FOR BLOOD VESSEL ANASTOMOSIS*

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RECENT advances in vascular surgery have been secondary to many factors, among which has been the development of better instruments and sutures for applying tried and reliable techniques. As a result, blood vessel anastomoses in the chest, abdomen, and extremities are being performed with increasing frequency.

The most common types of suture techniques used today are the over-and-over Carrel suture and the everting mattress suture popularized by Blalock. The latter suture has many advocates because it results in a smooth alignment of the intima with a minimum of intervening suture material. Its disadvantage, when compared to the Carrel over-and-over suture, is that more time is required when the needle must constantly be changed on the needle holder to reverse the suture.

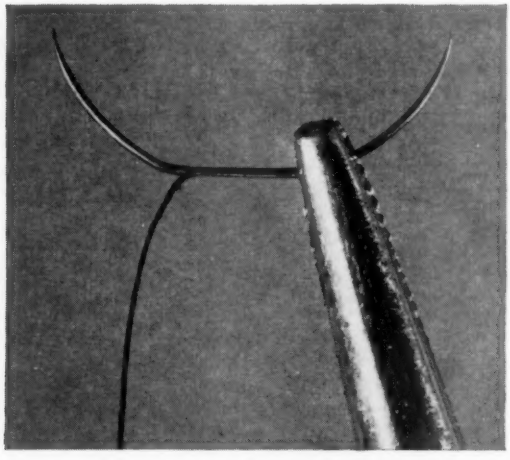

Fig. 1.—Photograph of new two-way suture needle. Note that both ends are pointed and 00000 braided arterial silk is swedged in the center.

It is natural that surgeons would seek methods of simplifying anastomotic procedures as long as good eversion of the suture line is maintained. Since blood vessel anastomoses are being more frequently performed, a new "two-way" suture needle has been developed to simplify the everting mattress technique without altering the basic suture pattern.

The "two-way" suture needle consists of a curved needle, pointed at both ends with the thread swedged in the center (Fig. 1). Because of its pointed ends, the needle can be passed in either direction without reversing it on the needle holder.

Received for publication July 1, 1954.

*This needle has been made to our specifications by the Ethicon Suture Laboratory and will soon be in production. We are indebted to Ethicon for their cooperation and perseverance in perfecting this new swedged needle.

The needle is advanced through the vessel walls in one direction, and when the forward tip is clear of tissue, it is grasped with the needle holder and pulled on through. Because of its double points, the rear tip of the needle is immediately ready to traverse the tissue in the opposite direction (Fig. 2). The advantage of this technique is that no time is lost during the operative procedure because of the repetitious unclamping, reversal, and reclamping of the standard type of needle.

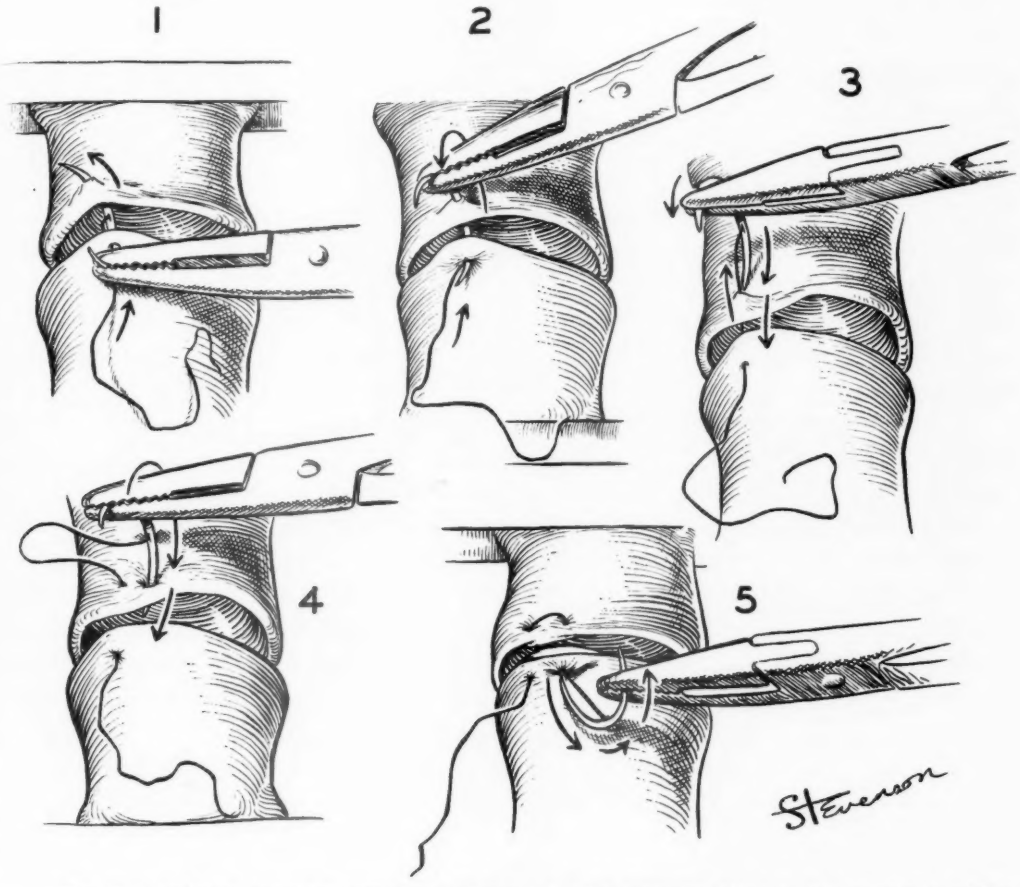

Fig. 2.—Drawing showing technique of use. *1*, The primary bite; *2*, the needle is picked up and pulled on through; *3*, with the needle holder still attached to the needle; *4*, it is ready to traverse the tissue in the opposite direction; *5*, the presenting tip is again picked up, the needle pulled on through, and it is again ready to start in the opposite direction without removing the needle and reversing it on the needle holder.

SUMMARY

1. A new two-way needle for blood vessel anastomosis is presented.
2. Application of this technique in experimental animals has proved it to be advantageous.

CONCLUSION

Preliminary impressions suggest that this new two-way suture needle might prove invaluable in many of the standard blood vessel techniques of today.

NOTES ON CONSERVATION OF GASTRIC AND DUODENAL FUNCTION IN PALLIATIVE ESOPHAGEAL RECONSTRUCTION

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SEVERE dysphagia is a symptom distressing enough, we believe, to warrant extensive surgery for its relief. The surgical relief of dysphagia in nonresectable neoplasm of the esophagus requires restoration of continuity of the alimentary tract by one of several substitution procedures.

The purpose of this communication is to review some of the techniques that have been heretofore utilized and to report a case in which the substernal tunnel method, first described by Robertson and Sarjeant,[1] was used. However, the physiologic advantages obtained by conserving gastric and duodenal function in re-establishing gastrointestinal continuity are here utilized.

The first attempt at complete replacement of the esophagus was made by Roux[2] in 1907. He performed the first stage of the procedure by mobilizing the jejunum with the mesentery, but never completed the operation.

Herzen[3] in 1908 was the first to replace the esophagus successfully, although other attempts had followed the original endeavor by Roux.

Several modifications by different surgeons followed these original procedures. An excellent historical review of the many techniques was made in 1946 by Rienhoff,[4] who in 1942 first successfully employed a jejunal segment within the thorax to replace the esophagus. All previous surgeons had transplanted the jejunal segment subcutaneously in front of the sternum.

Intrathoracic transplantation of the jejunal segment requires a shorter loop of intestine and therefore less mobilization and interference with the blood supply.

Until recently, operations utilizing jejunal transplants to replace the esophagus were performed in stages requiring from a few weeks to several months to complete the procedure. In 1950 Robertson and Sarjeant[1] reported the utilization of the anterior mediastinum for the placement of the jejunal segment, and the operation was performed in one stage. The operation was first performed in patients with carcinoma and later in patients with benign strictures. These authors found that patients did not do well with an antiperistaltic loop of jejunum as prepared by Rienhoff. This method was therefore abandoned in favor of an isoperistaltic loop of jejunum.

We feel that the operation previously described is a significant improvement over earlier methods. However, in by-passing the stomach and duodenum, certain important physiologic considerations are neglected.

Received for publication June 28, 1954.
†Died July 9, 1954.

The main function of the stomach is that of a food reservoir. This allows the individual to consume more food at each meal and thereby obviates the need for multiple between-meal feedings and the distressing symptoms of postgastrectomy dumping syndrome.[5]

In addition, the contact of food with the antral mucosa stimulates the production of gastrin, which in turn increases the production of HCl, so important in the absorption of iron and calcium.

The passage of food mixed with gastric chyme across the duodenal mucosa stimulates the production of a hormone, secretin, which is directly responsible for the stimulation of pancreatic secretion and also increases bile production. The importance of these substances to normal digestion needs no emphasis. By-passage of the duodenum not only results in a decreased production of these ferments, but there is inadequate mixture of them with the food and they trail the food, as is were, through the bowel. It is well documented that nitrogen and fat losses in the stool are greater when the duodenum is by-passed.[6, 7]

We are prompted to report the following case of a patient with nonresectable esophageal carcinoma in which a jejunal loop was transposed through the anterior mediastinum, the stomach and duodenum being utilized in re-establishing gastrointestinal continuity.

CASE REPORT

A 43-year-old Negro man was admitted on Feb. 20, 1953, complaining of progressive dysphagia for eight months. A diagnosis of squamous cell carcinoma of the lower one-third of the esophagus was established. The patient was able to take no solid food and only a small amount of liquid food by mouth. At thoracotomy on Feb. 27, 1953, the lesion was found nonresectable. On March 16, 1953, when dysphagia had increased to the point that liquids could not be retained, it was decided to attempt to restore the continuity of the alimentary tract, since the patient was otherwise in fairly good general condition. On March 20, 1953, with two operative teams working simultaneously, an isolated segment of jejunum was brought through a substernal tunnel in the anterior mediastinum, the proximal end anastomosed to the transected cervical esophagus and the distal end to the fundus of the stomach. Jejunal continuity was restored by an end-to-end anastomosis, while the distal esophageal segment in the neck was closed and left in situ. The patient tolerated the surgery well, and the immediate postoperative period was uneventful. Oral fluids were started on the fourth day and solid foods were well tolerated by the tenth day. He experienced no further difficulty on swallowing, was ambulatory, gaining weight, and quite comfortable until shortly before death, when he developed bilateral bronchopneumonia with pleural effusion; he expired May 29, 1953.

TECHNIQUE OF OPERATION

Details of the operative technique need not be given in this report since essentially the same procedure was used as that of Robertson and Sarjeant[1] with the exception that the jejunal loop was completely isolated and the distal portion of the loop was anastomosed to the gastric fundus so that gastric and duodenal function was preserved. Figs. 1 and 2 illustrate the technique used in this patient.

DISCUSSION

The case here presented was approached solely from the standpoint of palliation, since the patient was rapidly becoming unable to swallow and curative surgery was out of the question. Our experience with deep x-ray therapy

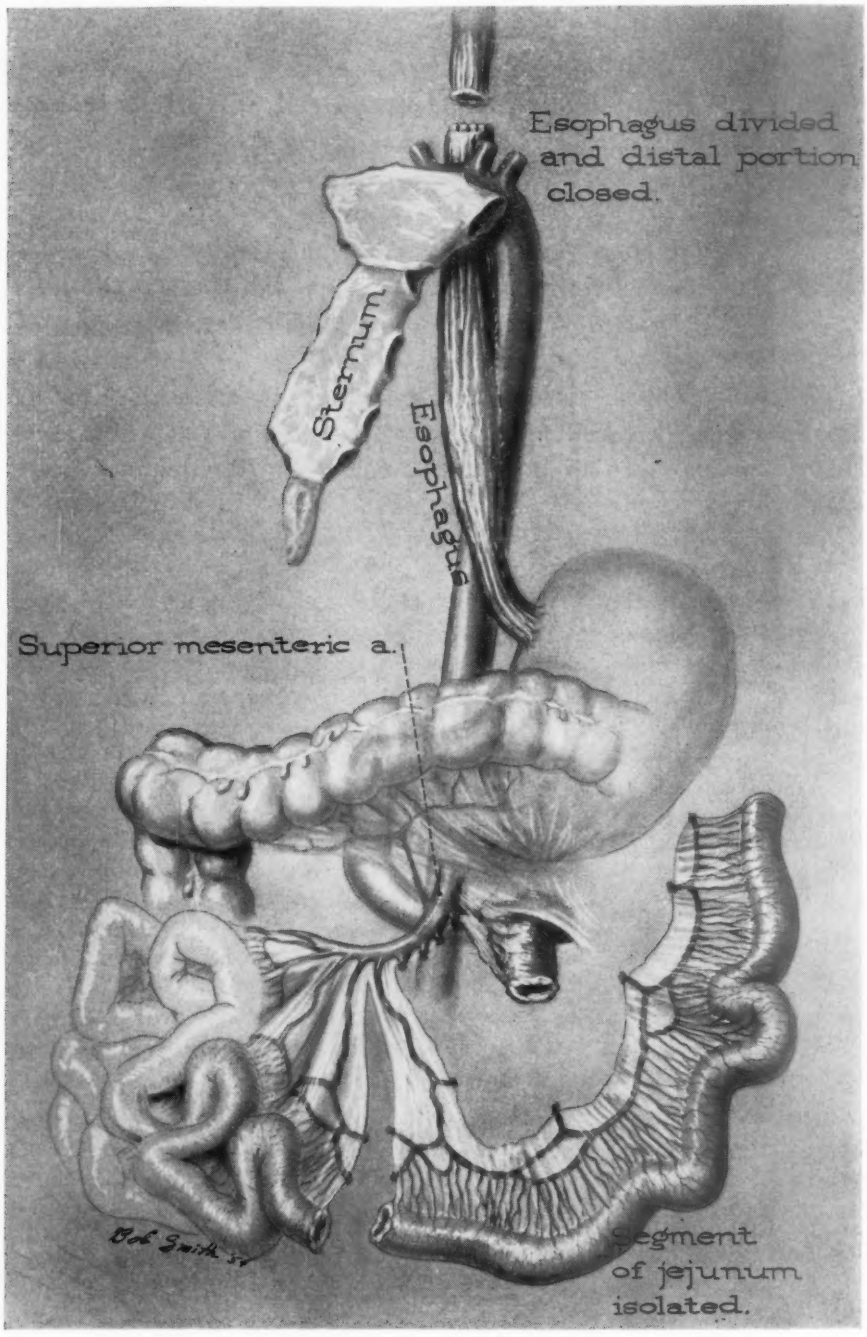

Fig. 1.

as a palliative measure in esophageal lesions of this extent has been unsatisfactory. A simple shunt operation such as may be performed in inoperable cancer of the lower end of the esophagus was not feasible. The procedure as outlined previously was well tolerated by the patient; he was able to swallow without discomfort, and during the remainder of his life was extremely

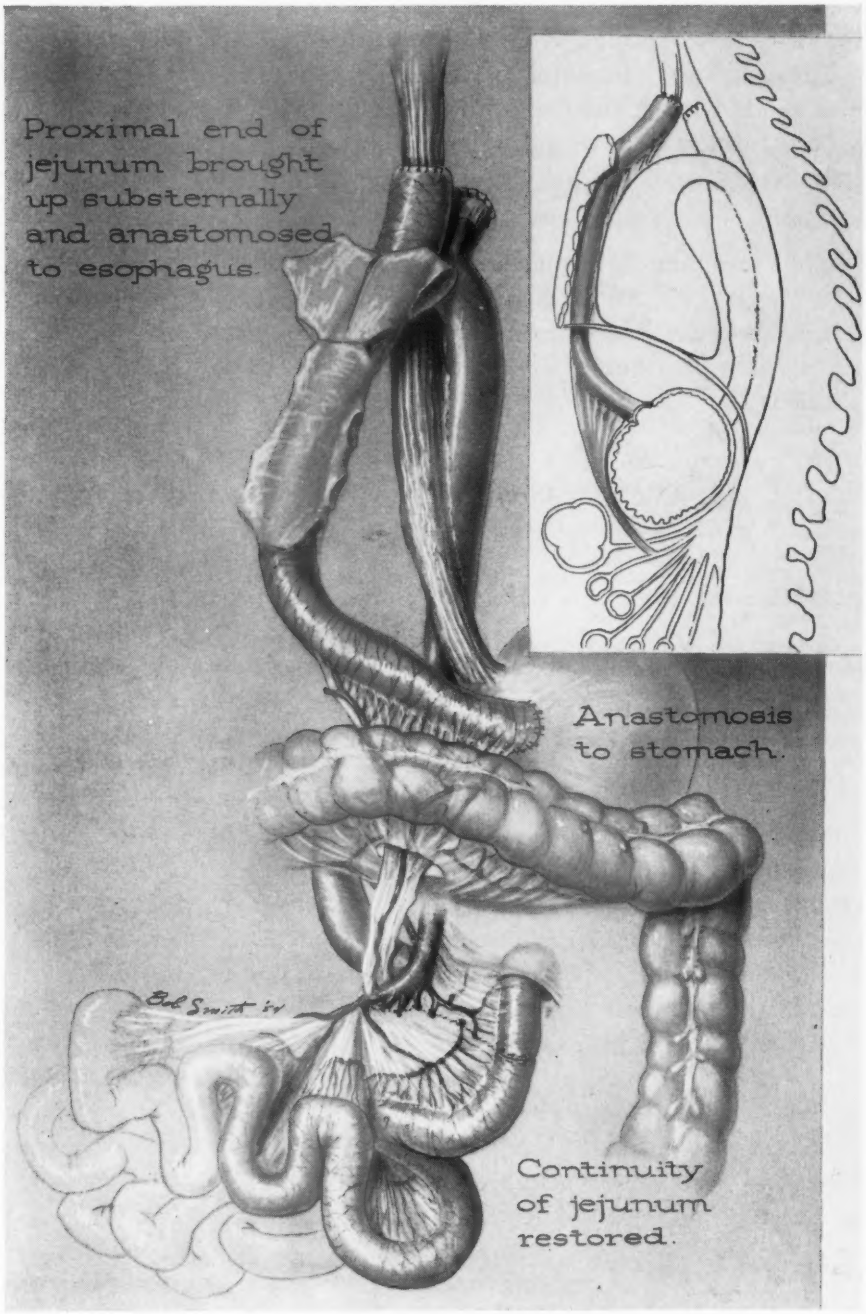
Proximal end of jejunum brought up substernally and anastomosed to esophagus.
Anastomosis to stomach.
Continuity of jejunum restored.

Fig. 2.

grateful for the relief of the dysphagia alone. Although the survival period in this case was short, we believe that the palliation which was afforded justified the surgery and that where longer survival periods may be anticipated, the results will be even more gratifying.

The indications for this modification of an accepted procedure may be extended to include extensive esophageal resections in which it is desirable to utilize the functions of the stomach and duodenum.

A gastrostomy was not performed postoperatively and distention did not occur. The esophagojejunostomy healed without leakage. Oral liquids and then solid foods were instituted rather rapidly and tolerated without mishap.

The advantages of the substernal placement of the jejunal loop have previously been described.

CONCLUSION

Complete esophageal replacement for nonresectable carcinoma was performed in one stage. An isolated isoperistaltic jejunal segment was utilized for the reconstruction and placed in an anterior mediastinal tunnel behind the sternum. Gastric and duodenal function was preserved. Gratifying palliation was obtained.

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HEPATIC LESIONS OF ACUTE HEMORRHAGIC PANCREATITIS

Their Nature and Pathogenesis

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ALTHOUGH much has been written concerning the experimental and clinical aspects of the pathogenesis of acute hemorrhagic pancreatitis, relatively little attention has been directed toward the liver changes occurring in this disease. Focal hepatic necrosis was reported by Adamski,[1] and Truhart[2] noted the occurrence of fatty and parenchymatous changes of a nonspecific nature in thirty-five of forty-seven cases of pancreatitis with fat necrosis and jaundice. Archibald[3] observed from his experiments that hepatic necrosis occurred consistently both in fatal and in nonfatal cases of induced pancreatitis. Schiller[4] observed alteration of hepatic architecture in six of nineteen cases of acute pancreatitis; the liver in one revealed fat necrosis. Eloesser,[5] from a review of the literature and his own cases, indicated that fatty and parenchymatous degeneration were the outstanding hepatic lesions associated with pancreatitis.

The purpose of this report is to draw attention to the hepatic changes that were noted from a histopathologic study of the livers in cases of acute hemorrhagic pancreatitis, and to discuss the pathogenesis of such lesions. The correlation of the parenchymatous hepatic changes and the jaundice frequently observed in this disease will also be commented upon.

METHOD AND MATERIAL

Records of fourteen consecutive cases of acute hemorrhagic pancreatitis during the ten-year period (1944-1954) were obtained from the autopsy files of the Cleveland Clinic Hospital. All the cases were characterized not only by the gross features of hemorrhagic pancreatitis, but by extrapancreatic fat necrosis as well. In two instances the process was limited principally to the head of the pancreas, whereas in the remainder of the cases the changes were apparent throughout the major portion of the gland. Hemorrhagic pancreatitis was given as the principal cause of death in each case.

In the group of fourteen patients, nine developed the disease following a surgical procedure for an unrelated disorder (Table I). The time of onset in this group of nine varied from twenty-four hours to one week following operation. The remaining five cases represent examples of "spontaneous" or "primary" disease. In no instance was there a biliary calculus or other physical obstruction that might have been the source of hepatic lesions.

Received for publication July 14, 1954.

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TABLE I. INCIDENCE OF ACUTE HEMORRHAGIC PANCREATITIS IN NINE CASES FOLLOWING SURGICAL PROCEDURES UNRELATED TO PANCREATIC DISORDERS

Subtotal pancreatectomy for carcinoma	1
Subtotal gastrectomy for carcinoma	2
Cholecystectomy	2
Total gastrectomy for carcinoma	1
Abdominal perineal resection	1
Bilateral hemiadrenalectomy	1
Duodenal diverticulectomy and gastroenterostomy	1
Total	9

An average of two sections of pancreas and liver from each patient was available for microscopic study. The tissues had been fixed in Zenker's fluid, embedded in paraffin, taken to water in the usual manner, and stained with hematoxylin, eosin, and methylene blue. In addition, an average of two sections of liver, similarly prepared, from each of twenty-five patients who had had fatal peritonitis were studied as controls, for comparison with the liver lesions observed in pancreatitis. These were chosen at random from a larger group of cases of fatal peritonitis after eliminating those patients in whom associated disease of the liver or biliary tree was present.

RESULTS

Hepatic lesions, exclusive of fatty metamorphosis, were observed in eleven of fourteen cases (78.6 per cent) of acute hemorrhagic pancreatitis (Table II). The most frequent change was bile stasis, as evidenced by round, homogeneous, dark green thrombi, or larger, irregularly shaped lakes (Fig. 1). Also evident were casts of inspissated bile conforming to the configuration of the bile capillaries and thus permitting easy recognition of those structures (Fig. 2). Hepatic necrosis, which was associated with bile stasis in four instances, was either focal (Fig. 3), without zonal preference, or manifest as irregular, broad zones with hemorrhage and cellular degenerative changes with dissociation of liver cell cords involving large portions of one or more lobules (Fig. 4). Focal hepatic necrosis was observed with nuclear pleomorphism in one case.

TABLE II. TYPE AND INCIDENCE OF HEPATIC LESIONS (EXCLUSIVE OF FATTY CHANGE) IN ELEVEN OF FOURTEEN CASES OF ACUTE HEMORRHAGIC PANCREATITIS

Necrosis (With bile stasis—4) (With nuclear pleomorphism—1)	5
Bile stasis (With necrosis—4)	7
Pericholangitis (With nuclear pleomorphism—1)	1
Nuclear pleomorphism and mitoses (With pericholangitis—1) (With necrosis—1)	3

In three instances nuclear hyperchromasia, pleomorphism, and abundant mitoses (up to ten per high-power field) were present (Fig. 5); cellular necrosis was present in one of these. A marked neutrophil and lymphocyte infiltrate was noted about the biliary radicals in one case in which nuclear change was evident (Fig. 6). However, in no instance were abnormalities of the epithe-

lium of the duct found. Intraductal exudate similarly was not apparent. The hepatic lesions enumerated appeared as frequently in the primary as in the postoperative examples of pancreatitis. Fat necrosis, intracellular calcification, or vascular lesions were not observed. Although material was not available for the detection of fatty acid crystals, it seems unlikely that such structures would be present in the absence of fat necrosis.

Jaundice, as indicated in the clinical records, was present in all but two of the patients having pancreatitis accompanied by hepatic lesions as described previously; the liver from one patient without jaundice revealed bile stasis and from the other, focal necrosis. Conversely, jaundice was not observed in those patients who had no hepatic lesions.

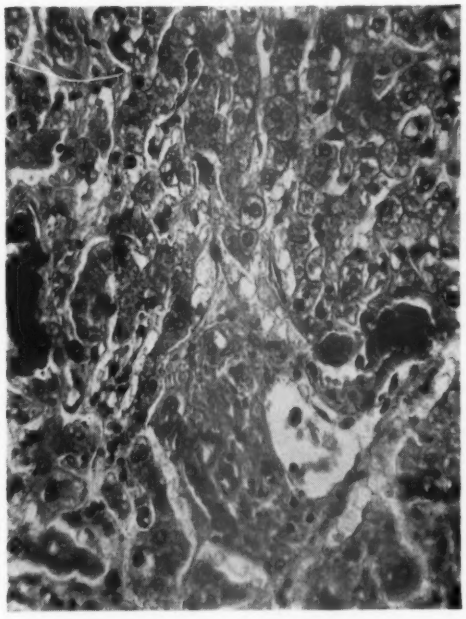

Fig. 1.

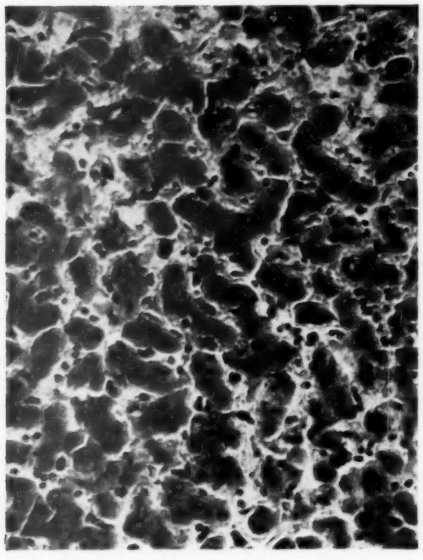

Fig. 2.

Fig. 1.—Section of liver revealing large "lakes" of inspissated bile. (×300; reduced ¼.)
Fig. 2.—Section of liver demonstrating bile thrombi of the capillary type. The biliary radicals are well demonstrated. (×270; reduced ¼.)

Of the twenty-five cases of general peritonitis in the control group, only one revealed focal necrosis. The liver sections of another demonstrated nuclear pleomorphism and an occasional mitosis. Thus, in only 8 per cent of the control group was there demonstration of lesions similar to those observed in acute hemorrhagic pancreatitis. None of the group were clinically jaundiced.

COMMENT

The pathogenesis of the hepatic changes observed in acute pancreatitis has not been clearly understood. The two most prevalent concepts as to the etiology of these liver changes are: (1) the toxic theory and (2) the pancreatic reflux theory. The possibility that "toxins" cause the parenchymatous lesions was suggested by Marx,[6] who believed that noxious agents were carried to the liver by the portal tributaries. Fischler,[7] who also subscribed to the

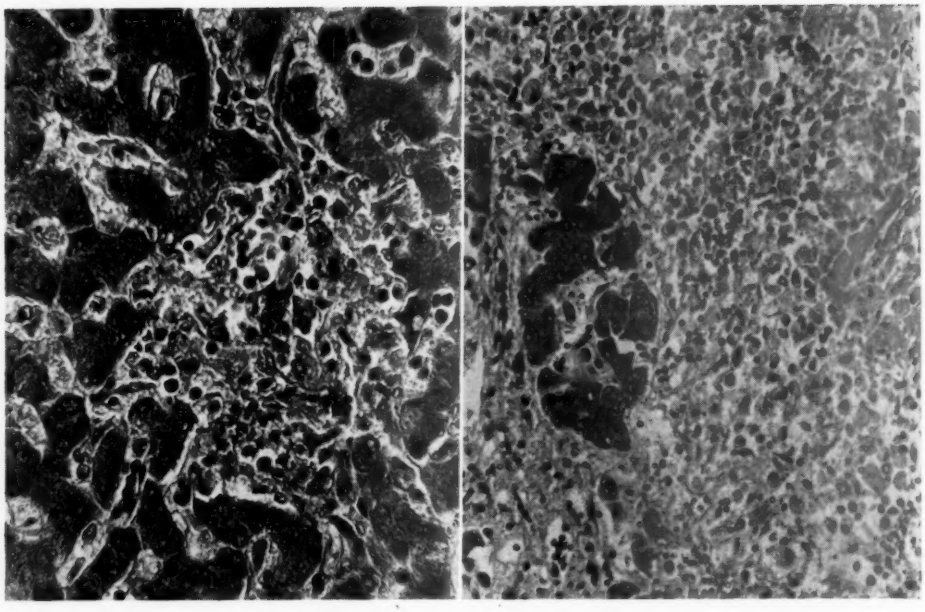

Fig. 3. Fig. 4.

Fig. 3.—Section demonstrating focal necrosis of liver. (×400; reduced ¼.)

Fig. 4.—Section demonstrating a large area of hemorrhagic necrosis with destruction of a large area of a liver lobule. (×240; reduced ¼.)

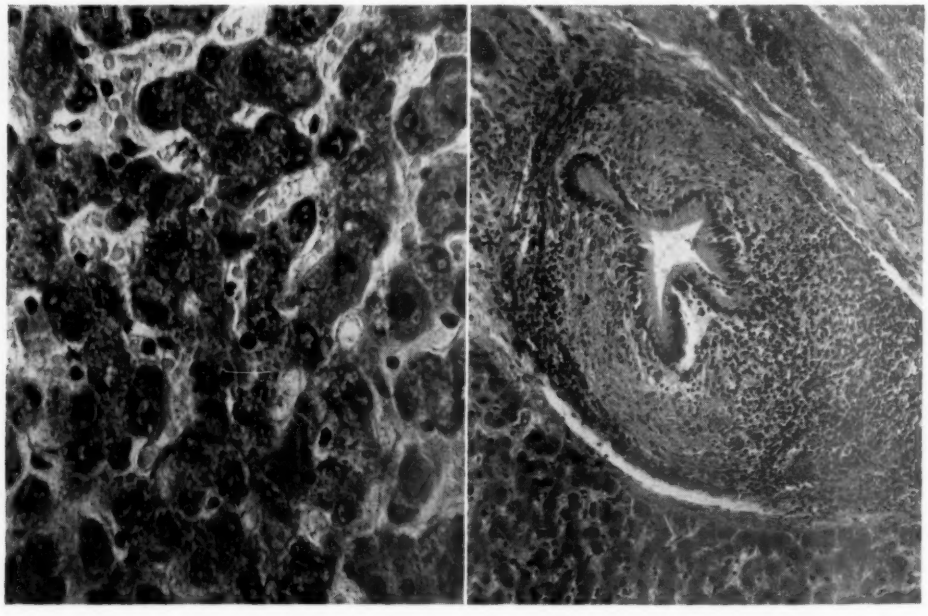

Fig. 5. Fig. 6.

Fig. 5.—Section demonstrating liver cell mitoses. Four mitotic figures are noted within this section. (×400; reduced ¼.)

Fig. 6.—Section demonstrating pericholangitis. The epithelium of the duct remains intact. (×140; reduced ¼.)

toxic theory, concluded from his studies of dogs that the lymphatics offered a convenient route for the transmission of such stimuli to the liver. Since cultures of the pancreas in acute pancreatitis fail to reveal bacterial growth, it is presumed that such toxins are derived from the products of tissue necrosis encountered in this disease. Evidence for refuting the toxic theory is lacking in this study. Further, the hepatic lesions do not appear to be specific for pancreatitis since they were observed to occur, albeit infrequently, in the control group. Moreover, Kimmelstiel and associates[8] noted that similar changes occurred in chronic nonspecific ulcerative colitis, as well as less frequently in a control group of 1,000 cases that excluded all cases of diseases of the biliary system, septicemia, exogenous toxins, vascular lesions, and trauma. Hepatic lesions similar to those described in this study are well recognized as occurring in those cases that were excluded by this group of investigators.

Yet, as Kimmelstiel and his associates[8] have indicated, in chronic ulcerative colitis the increased incidence of such changes implies the presence of other factors. It is noteworthy to mention that in Kimmelstiel's study the incidence of hepatic lesions in ulcerative colitis was approximately three times greater than in his control group, whereas in our investigation lesions were noted within the liver ten times more frequently in patients having pancreatitis than in those of the control group. That the reflux of pancreatic secretion is a significant factor in the pathogenesis of these liver lesions is supported by the observations of many investigators. Schiller,[4] as indicated previously, has observed the presence of fat necrosis within the liver of a patient succumbing to acute pancreatitis. He also cited the work of Popper, who recovered an increased amount of amylase from thirty-seven (17 per cent) of 219 examinations performed on bile obtained from the gall bladder and biliary tree at the time of operation; in nineteen of the thirty-seven of these cases, acute or chronic pancreatitis was present. The experiments of Bisgard and Baker[9] and Wolfer[10] similarly indicate the presence of pancreatic reflux. Colp and Doubilet[11] for a long time have advocated the theory that pancreatic reflux plays a role in biliary tract disease. Mirizzi[12] concluded from his cholangiographic studies of human beings that although the bile flow usually is directed into the pancreas, frequently the flow is reversed.

The hepatic lesions observed in this study, in general, are not suggestive of being the result of enzymatic action. Fat necrosis was not present despite the frequently severe fatty changes which, according to Schiller,[4] are essential for such a reaction. Yet, the same type of parenchymatous hepatic changes (that is, focal necrosis, bile stasis, nuclear pleomorphism, and mitoses) has been observed previously by one of us (E. R. F.)[13] following experimental pancreatic reflux in the dog. Such observations inferentially indicate that the response of the hepatic parenchyma to pancreatic secretions may in some instances be reflected in the otherwise nonspecific parenchymatous lesions of focal necrosis, bile stasis, and nuclear pleomorphism, hyperchromasia, and frequent mitoses. In addition, the broad zones of hemorrhagic necrosis noted in several instances in this study are suggestive of marked proteolytic activity

rather than a simple toxic manifestation. Vascular lesions other than the presence of hemorrhage, which might be expected to occur with tryptic digestion, were not noted, however.

The results of this study indicate that another factor in addition to pancreatic reflux may be operative in the production of the hepatic changes. The occurrence of bile stasis has not been emphasized as a hepatic lesion accompanying acute pancreatitis, yet it represented the most frequent hepatic alteration observed in this study. Although cholecystitis and cholelithiasis were noted in one-half the cases of pancreatitis examined, as mentioned previously, mechanical obstruction as by calculi was not demonstrated, and in two cases with cholecystitis and calculi, hepatic changes were not present. The presence of bile stasis, particularly the capillary type, may be explained on the basis of cellular injury, for such a change is noted in viral hepatitis, even in the preicteric phase. Yet, the histopathologic appearance of thrombi and large lakes of bile suggest extrahepatic obstruction. Since a physical basis for such a phenomenon was not apparent, the possibility appears tenable that regurgitation of bile may be brought about by increased back pressure within the biliary system by means of pancreatic reflux with or without the existence of sphincter spasm. Spasm of the sphincter musculature has been considered by some as an etiological factor in the pathogenesis of pancreatitis. Although it has been demonstrated that the sphincter musculature may be distributed about both the common and the pancreatic ducts as well as below the site of entrance of the pancreatic duct, such anatomic variations would not influence the development of marked bile stasis in the presence of sphincter spasm. In addition, common duct obstruction might occur as a result of edema and other pathologic changes in the head of the pancreas in those instances in which this structure passes through the head of the pancreas. The absence of lesions of the biliary radicals other than pericholangitis should not be considered as offering evidence against the role of pancreatic reflux in the pathogenesis of the hepatic lesions observed, in the light of Schiller's[4] observations on the resistance of these structures to fermentative action.

Morphologically it appears that the previously described liver changes probably would not influence the course of acute hemorrhagic pancreatitis, although allowance must be made for the limitations of morphologic evaluation of liver function. Liver function tests were performed on three patients with hepatic lesions, and no deviation from the normal was found. In an additional six patients, blood total protein determinations also were normal. It is interesting to note that there was no elevation of the nonprotein nitrogenous substances in the blood except in three instances, and these revealed hemoglobinuric nephrosis, in one instance caused by sulfonamide toxicity. Yet, instances of the hepatorenal syndrome have been recorded as occurring in acute pancreatitis. The occurrence of jaundice in pancreatitis, however, appears to be adequately explained on the basis of the hepatic lesions noted. This explanation is substantiated by the presence of jaundice and bilirubinemia in eight of the ten patients in whom there was hepatic change, and the absence

of these signs in those in whom no liver lesion was detected. The frequent finding of marked bile stasis and the apparent pathogenesis of such changes also substantiate this contention.

SUMMARY

A study of the livers from fourteen patients who had fatal acute hemorrhagic pancreatitis revealed lesions (excluding fatty change) in eleven, or 78.9 per cent. The most frequent changes noted were bile stasis and small as well as large irregular focal zones of necrosis. In addition, pericholangitis and nuclear pleomorphism and mitotic activity in liver cells were also noted. These lesions were ten times more frequent in patients having pancreatitis than in a control group of twenty-five patients who had had fatal general peritonitis.

The pathogenesis of the liver lesions in acute hemorrhagic pancreatitis appears to be more adequately explained on the basis of pancreatic reflux rather than as being the result of endogenous toxins. The frequent appearance of bile stasis of obstructive type lends support to the concept of sphincter spasm in acute pancreatitis, since in no instance were physical factors demonstrated which might account for such a change.

Although the lesions, for the most part, do not appear to be of sufficient magnitude to act as contributing factors in the death of the patients, the role of these lesions in the production of jaundice and bilirubinemia is apparent. Jaundice was observed in seven of nine of the patients who had such liver changes, whereas in those patients without such alterations this sign was absent.

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SQUAMOUS-CELL CARCINOMA OF THE ANUS: RESULTS OF TREATMENT

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SQUAMOUS-CELL carcinoma of the anus is a rare lesion but one encountered frequently enough to present a very definite problem to the surgeon. The nature of adenocarcinoma in the lower part of the rectum is much better understood, and the treatment for that lesion appears to be well documented and familiar to all. Up to the present, however, the situation is anything but stable in regard to squamous-cell epitheliomas.

When surgeons first became somewhat familiar with removal of the anus and its sphincters they naturally turned to that type of operation for the occasional squamous-cell lesion. The early outcome interpreted in the morbidity and mortality studies had the obvious effect, namely, surgical treatment soon fell into disrepute. Following that period, there was an intermediate interval when enthusiastic radiation therapists (especially in continental Europe) had demonstrated seemingly good results with malignant tumors elsewhere in the body, so that for a rather prolonged period that type of treatment was selected for many patients suffering from squamous-cell lesions of the anus. In fact, so enthusiastic were these radiotherapists that down to the present time many internists are prone to consider the treatment to be no problem; their patients receive radiation with little or no regard for the possibilities of radical surgical removal of the lesion.

A general dissatisfaction with nearly all forms of therapy came over the entire profession in relatively recent times. Some controversy seems apparent in reading reports presented by surgeons, proctologists, internists, and radiotherapists. Once again the various enthusiasts redoubled their efforts in various directions; naturally, the recent advances in the form of adjuncts to surgical care (which have extended the frontier so dramatically of late) brought radical resection into the discussion regarding these squamous-cell lesions. For a long time the importance of the inguinal lymph nodes and even the iliac lymph nodes had been well known to the surgeons as well as the anatomists. The early resections of the anus were discussed in connection with plans for a later dissection of the inguinal nodes. That much of this was theoretical is apparent from a casual study of the literature. Along with the radical developments in the surgical field today, one is made quite aware of the present radical trend in radiotherapy. If smaller doses of treatment seem somewhat effective in some cases, perhaps it is within the realm of possibility

The Mayo Foundation is a part of the Graduate School of the University of Minnesota.
Received for publication June 29, 1954.
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that much more intensive doses might be more effective. The surgeon will welcome any new information that his colleagues in radiotherapy may have to offer.

We had become confused in our own minds as to just what type of treatment is best for squamous-cell carcinoma of the anus. In our own institution the internists appeared earlier to be divided in opinion as to which section they should consult for treatment for these patients. The surgeons in the intermediate years gradually became convinced that they could derive a better result by surgical removal than by any other method. In fact, Dixon has stated that it has been a long time since he has relied on radiation therapy for this lesion. Mayo has pointed out that he has been discouraged in attempting to evaluate the true picture because so few authorities have dealt with large enough series employing any single method that adequate information is still not available.

REVIEW OF THE LITERATURE

In turning to the reports which have been presented in more modern times we had hoped to develop some idea on the comparable effects of the several methods of treatment still in practice in various centers. However, we too have been somewhat disappointed because no one physician has treated a large enough series in any one manner. We appreciate that since time was all-important no authority wished to withhold from any patient any possible benefit which might be derived. Nevertheless, the result has been a mixture of treatments in many cases.

I. *Modes of Spread.*—A. *Lymphatic routes:* The early anatomists were quite well acquainted with the lymphatic drainage of the anus. This is borne out by the early if somewhat crude attempts not only to remove these lymphatics, but also to treat them by other means. An excellent review of the various routes involved is presented by Rouvière. The inguinal nodes are stressed by most authors, and more recently the role of the iliac nodes is being appreciated. The nodes of the superior mesenteric region have been emphasized by many also; Pack and Rekers have presented a clear idea of this zone especially in regard to tumors in this area, and certainly there can be no quarrel with their conclusions. Cattell and Williams re-emphasized the practical aspects of this knowledge and summarized the experiences at the Lahey Clinic in dealing with this type of lesion.

B. *Blood vessel metastasis:* The tremendous importance of this mode of spread in rectal adenocarcinoma is familiar to all. Many authorities appear to be in agreement, however, that for the squamous-cell lesion of the anus the blood vessel route is considerably less important. Cattell and Williams found this to be true in their series, and more recently Grinnell, in analyzing data on forty-nine cases, concluded that the blood vessel route was definitely of secondary importance.

C. *Direct extension:* As might be expected, the problem of direct extension was of primary concern in most of the series presented. Not only are the adjacent structures vital, but the prostatic area and the seminal vesicle lym-

phatic plexuses have a very important bearing on treatment and prognosis. This has been brought out by Buxton, who has underscored the extreme importance of the posterior vaginal wall. Buxton includes that structure in his routine resection for lesions of this nature. He agreed with others that the levator area, the anal sphincters, and the entire perineum are indeed vulnerable to attack by squamous-cell carcinoma.

II. *The Role of Radiation Therapy.*—In an earlier decade enthusiasm for treatment with x-rays or radium alone became rather widespread. Much of this enthusiasm originated on the European continent and, indeed, in occasional isolated series the results quoted do appear to be rather satisfactory. Bensaude and his co-authors were responsible for some of this enthusiasm, but critical analysis brought out that their series was, indeed, small. In a later decade some rather sharply conflicting evidence was presented by Sweet. Unfortunately, once again a very small series of cases formed the basis for the conclusions in regard to x-ray therapy alone, but he did find that not one patient was alive one year after the treatment. He found that the results were rather better when radium was the agent selected.

The surgeon is not the only one to be hesitant in regard to this type of treatment because of the drawbacks of complications produced. The internists and family physicians have long been dissatisfied because of the rather constant pain which results and requires constant attention. In addition, tenesmus is the rule and an annoying, seemingly interminable discharge from the anus will make some of these patients quite miserable. As one would expect, the healing of the perineum in many cases is far from satisfactory. Grinnell has been as outspoken as any in pointing this out.

III. *The Role of Inguinal and Iliac Lymph Node Dissection.*—As mentioned previously, the theory behind this surgical maneuver would appear quite sound. If one could in any way liken this to a lesion in the breast or perhaps a lesion treated satisfactorily by a radical block neck dissection, the theory would remain quite tenable. Pack and Rekers have presented a strong argument for this step. Cattell and Williams have summarized the Lahey Clinic experience. In the light of present knowledge of anatomy one would expect far better results if such an operation were to be routine. In summarizing the literature, however, one derives the impression that the actual performance of an inguinal and iliac node dissection in practice may leave a great deal to be desired. Buxton has presented a rather enthusiastic endorsement of extending the frontiers by a very rigid plan which would demand this type of operation performed in stages. Grinnell, however, although he was fully aware of the theoretical advantages, found that inguinal node metastasis was relatively infrequent. In fact, it occurred in only four of his patients. He thought that this was evidence of an extremely late stage of disease and that perhaps one would derive far better results by concentrating on radical surgical removal in the extremely early stage rather than procrastinating with ineffective treatments until a hopeless stage had developed.

IV. *Results of Treatment.*—To base one's conclusions on the study of the literature alone would result in a certain state of confusion. It would appear

that a rather different attitude is held at present depending on whether one is a proctologist, a surgeon, an internist, or a radiotherapist. The greatest agreement among all these specialists seems to be that the results at best are discouraging over any long period of study. Gabriel concluded that low-grade lesions definitely revealed better results with radium treatment alone. Kerr presented the thesis that at least on a theoretical basis the patients would derive the best result by radical surgical resection followed by radium and x-ray. The present-day application of what might be called "superradical operations" sounds like a logical development along these lines, but the question is whether there is enough documented evidence in support of this. McQuarrie and Buie felt that the degree of differentiation of the tumor was extremely important, and analyzed data on a series of patients on that basis. However, they agreed that for any long-term study the results were indeed discouraging on the whole. Most of the authors felt that the series were all too small or had too short a follow-up period to be conclusive. Although many authors have now presented fairly sizable series of cases, when those series are divided into the various groups according to treatment there is very little control to the study.

PRESENT STUDY

We endeavored to determine for ourselves what situation has held true in our own institution in relatively modern times. Ideally, we would prefer to carry parallel series, studying first those patients treated with radiation therapy alone, contrasting them later with those undergoing surgical treatment alone. We immediately encountered the difficulty of a mixture of treatments, which all other investigators had found to be the case, but we have attempted to derive at least some information for our own future guidance.

The present series is made up of 122 consecutive cases of squamous-cell carcinoma of the anus seen at the Mayo Clinic during a period of time which we arbitrarily terminated in 1948. This gave at least a five-year follow-up period for every patient.

I. *Age and Sex.*—In the series there were 70 females and 52 males, which is in agreement with many previously reported series but which contrasts with a few we encountered in the literature. The youngest patient was only 4 years of age, an extremely rare situation indeed. The oldest was 79 years of age. We found that 7 patients were less than 40 years old; 31 patients were between 40 and 50 years of age; 36 between 50 and 60 years; 36 between 60 and 70 years; and 12 were more than 70 years of age.

II. *Pathology of the Lesions.*—Of the entire group we discovered that 5 were definitely those to be classed as in situ lesions. Of the others, 4 were mixed squamous-cell and basal-cell carcinomas. This is somewhat in agreement with other reported series, for many authors have noted a few of their cases having the mixture of the two elements. However, unfortunately for the patient, the behavior of the tumor was definitely that of a squamous-cell type and we found this to be definitely true in our series. The remaining 113 cases fell in Broders' grading scale (in which Grade 1 is the most differenti-

ated type of lesion and Grade 4 is that type in which there is very little, if any, differentiation). As might be expected, the great majority of the cases were Grade 2 and Grade 3.

III. *Results of Treatment.*—We previously mentioned the difficulty of separating the patients into clear-cut groups according to therapy. Many of the patients had started with x-ray therapy prior to registering at the clinic. Occasionally this was repeated here or followed by local application of radium. In addition, some of those patients who had intensive radiotherapy of one kind or another underwent sigmoid colostomy as part of their treatment. Since the amount of local tissue reaction produced by the radiotherapy often brought on obstruction of the anal canal, we arbitrarily decided that the performance of a sigmoid colostomy did not in any way enter the surgical picture as far as specific treatment on the lesion itself was concerned. This may be an unwarranted assumption, for one might conclude that the radiotherapist would feel free to increase his dosages knowing that a colostomy was present. However, for purposes of clarity, we did not consider colostomy alone as a part of surgical treatment for the lesion itself. In this regard it must be borne in mind that the performance of colostomy carries a certain small risk factor which for absolute correction of longevity statistics should probably be included.

TABLE I. SQUAMOUS-CELL CARCINOMA OF ANUS: GRADE OF LESION (BRODERS' METHOD): RESULTS OF TREATMENT (REGARDLESS OF METHOD)

GRADE	NUMBER TRACED	5-YEAR SURVIVAL (PER CENT)
1	3	33.3
2	33	42.5
3	42	35.7
4	22	9.1

A. *Results related to grade of lesion:* These results are presented in Table I, which bears out very well the experience reported by other authors. It is known that of those patients having Grade 2 lesions for whom we have accurate follow-up there was a 25.9 per cent ten-year survival rate. For Grade 3 lesions a 19.4 per cent ten-year survival rate is noted, but of the Grade 4 lesions, all patients were dead within ten years regardless of treatment. In general, the Grade 4 lesions were not approached with any degree of enthusiasm by the surgeons of earlier days.

TABLE II. SQUAMOUS-CELL CARCINOMA OF ANUS: FIVE-YEAR SURVIVAL AFTER TREATMENT

TREATMENT	NUMBER	5-YEAR SURVIVAL (PER CENT)
Radiation only	19	31.5
Local removal	9	62.5 (of 8 traced)
Local removal plus radiation	24	33.3
Radical resection	45*	36.3 (of 44 traced)

*Two hospital deaths: 1, pulmonary embolism; 1, cerebral thrombosis.

B. *Results according to the method of treatment:* We attempted to analyze these in as critical a fashion as possible and have presented the material in Table II. Here again the fallacy inherent in any small series of cases is borne out. However, we present the figures for what they are worth. As mentioned previously, a few of the patients received radiation alone and sometime during their course had undergone sigmoid colostomy. They are included in the "radiation only" category. If one were to overlook the size of the series undergoing local removal he might be tempted to conclude that the results there were excellent. However, quite in keeping with the reported experience of others, we have the definite impression that local removal is dangerous; had this series been considerably larger, we feel the results would

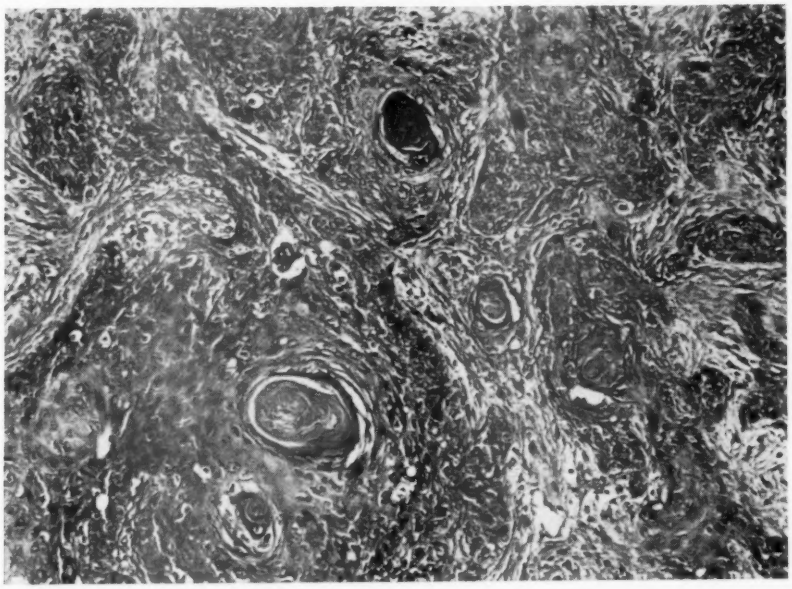

Fig. 1.—Typical squamous-cell lesion. The patient underwent radical Miles' combined abdominoperineal resection in one stage and is still working daily as a welder six years later with no sign of recurrence.

have been far less satisfactory. Speaking strictly from the surgical standpoint, we had developed the theory that local removal actually in modern-day practice should be looked on with considerable question. In regard to radical resection it is to be stressed that many of the patients had undergone intensive x-ray or radium therapy or both before finally being submitted to resection. One wonders whether a period of very valuable time was wasted and whether better results might not be obtained by proceeding very early with radical resection. Referring to the many reports in the literature, it would appear that involvement of lymph nodes (coming late as it does) is the factor which mars the record of this method. Early radical resection would probably prohibit the development of involvement of lymph nodes (Fig. 1).

C. *Results of treatment—"other categories":* It was somewhat difficult to place these patients in a logical category. Therefore, they have been grouped

together in Table III. From the information we have for ten-year follow-up studies, it is now known that 2 of the in situ patients are no longer living, but died of causes totally unrelated to the squamous-cell lesion. In regard to the mixed squamous- and basal-cell carcinomas, we found that several were treated by local excision alone but only 1 of the patients lived more than five years. Only 1 patient was treated by radical surgical resection but he died of his disease three years later.

TABLE III. SQUAMOUS-CELL CARCINOMA OF ANUS: RESULTS OF TREATMENT: OTHER CATEGORIES

CATEGORY	NUMBER	5-YEAR SURVIVAL (PER CENT)
In situ lesions	5	100
Mixed squamous- and basal-cell	4	50
Palliation only	7	0
Hopeless when first seen (no treatment)	9	0

It is difficult to draw any conclusion from such a small series, but it certainly appears that when the mixed lesion is present, the behavior is strictly that of the squamous-cell component, and from what we have been able to gather, the basal-cell element means nothing in regard to prognosis. In those patients who were considered hopeless when finally seen at the clinic, it was found that 1 had undergone local excision only elsewhere several years previously. One other patient had undergone very radical surgical treatment elsewhere, and this was followed by extensive x-ray therapy. The perineum was the site of marked recurrence complicated further by most distressing changes brought on by the x-ray. It was evident that nothing further was in order. Two other patients in this group had neglected themselves over long periods of time and had never consulted their physicians, so that no treatment had been given.

PROGRESS IN TREATMENT

Prior to undertaking the study, we had the impression that most of our surgeons have been attacking these lesions much more aggressively in recent years. To see whether this was actually true, we divided the present series into three different groups chronologically. The first group we arbitrarily ended at the 1937 level, the second group extended from 1938 through 1942, and the third group from 1943 to 1948. It was apparent that in the early years local excision was much more frequently used than later. In the intermediate period, radium and x-ray therapy seemed to be the type of treatment sought more extensively by the internists who first saw the patients. By 1943, a subtle change appears to have developed in which more radical approaches became more commonplace. A very radical Miles combined abdominoperineal resection performed in one stage (in which a more extensive removal of skin was carried out than is commonly the practice for adenocarcinoma of the rectum) seemed to compete with a two-stage combined abdominoperineal resection in which the second stage aimed for an extremely radical posterior excision. From the surgical standpoint it is somewhat disappointing to note that results in these three periods of time are not strikingly different. How-

ever, there are so many other factors apparent that conclusions are entirely misleading. It was noted that in the last period most of those patients undergoing radical surgical treatment had had repeated attempts at therapy previously and so perhaps it is not fair to attempt any comparison.

INGUINAL LYMPH NODE DISSECTION

One of the greatest disappointments of this study was the lack of decisive information in this regard. In the early years it was noticed that none of the patients were submitted to block dissections. In sporadic instances following that period one or both groins were dissected at varying periods of time after the definitive operation. A logical radical attack on a planned basis does not appear to have been the rule. In the intermediate years, a few patients, especially those who had undergone two-stage radical resections, were submitted to groin dissections with equivocal results. It appeared that the possibilities of added morbidity and mortality restrained the surgeons from submitting the patients to further distress without being able to promise a decided benefit from the dissections. Several patients who had obvious involvement of at least one inguinal node underwent dissection of one groin at the time of the resection. The results in these cases were uniformly poor.

The philosophy in more recent years has been somewhat as follows: If the patient has a lesion for which surgical treatment has anything to offer, early radical operation is the best plan. This eliminates the earlier scheme of local excision, radium, or x-ray and offers the benefit of radical removal at the earliest possible time. The cases in the present report seem to support this contention, although the evidence is not exactly overwhelming. Waugh has carried out an extremely radical one-stage Miles resection with simultaneous bilateral inguinal node dissection with excellent results. He feels that further consideration should be given to this plan. Although our series is lamentably small, we can record that when the nodes were not involved the bilateral dissections were attended by relatively good results. However, when the nodes were involved, none of the patients survived for five years, no matter how radical the approach.

SUMMARY AND CONCLUSIONS

1. Squamous-cell epithelioma of the anus still remains a problem in proper management. The record in this regard is not brilliant.

2. Surgeons should discard local excision except in extremely isolated instances.

3. Unwarranted enthusiasm for radium and x-ray therapy has led in the past to loss of valuable treatment time for some patients.

4. Poor survival statistics associated with some of the earlier radical operations are due to the late date at which surgical consultation has been sought, after other means have failed.

5. Radical resection in very early cases has been followed by satisfactory survival rates.

6. On a purely theoretical basis, radical resection should be coupled with bilateral dissection of inguinal lymph nodes. On a practical basis there is not enough cumulative evidence to prove this, since some patients appear cured without dissection and none of our patients with proved inguinal metastasis survived for five years after such dissection.

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SURGICAL TREATMENT OF CANCER OF THE EXTRINSIC LARYNX AND HYPOPHARYNGEAL WALLS

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FROM the point of view of the clinician, classification of tumors based on the specific anatomic origin of the lesion is the most valid foundation upon which to base reports of end results of treatment. Classifications based on histologic findings do not serve anywhere near as well. For example, a diagnosis of "lymphosarcoma" is not complete by itself until one specifies whether the lymphosarcoma arises from the tonsil or perhaps from the stomach. Similarly, the problems arising from treatment of an "adenocarcinoma" of the salivary glands are entirely different from that of an "adenocarcinoma" arising from the rectum.

Despite the validity of these statements, the application of the classification based on the anatomic site of origin of the tumors is not without its difficulties and flaws. These weaknesses can sometimes be traced to a lack of agreement on basic anatomic definitions. Nowhere is this better exemplified than in cancers arising in the general area of the hypopharynx. We freely grant that there is merit to distinguishing whether a growth arises on the base of the tongue, lateral pharyngeal wall, or extrinsic larynx. In actuality, however, the anatomy in this area is such that as the upper respiratory and digestive passages funnel toward the trachea and esophagus, the distance separating the outside wall of the larynx (for example) from the adjacent base of the tongue, or the base of the tongue from adjacent pharyngeal wall, is brief. Also, by the time the lesion is diagnosed, it has attained such large size that it is difficult to determine with accuracy just where it started. As a result of this, reports concerning the methods of treatment and end results on tumors arising in this area may be found under discussions pertaining to carcinoma of the larynx, base of tongue, pharynx, cervical esophagus, "laryngopharynx," hypopharynx, or even under such a general heading as "cancer of the throat."

This report will be a discussion of the surgical techniques designed to eradicate malignant tumors occurring in the area of the extrinsic larynx and hypopharyngeal walls. It is our feeling that the operation which entails a radical neck dissection, sacrifice of the larynx, and a portion of the pharyngeal wall or base of the tongue as indicated is applicable (with minor variations) to these tumors regardless of whether their point of origin is on the lateral

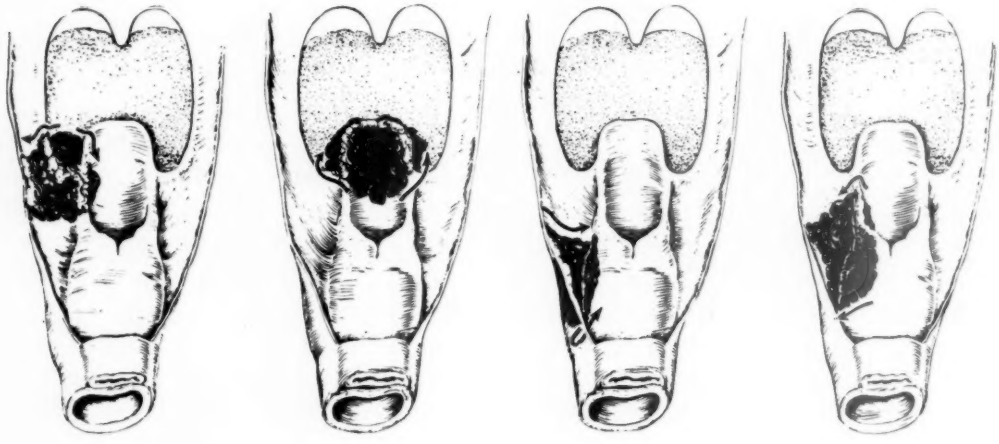
Aided in part by a grant from the Damon Runyon Memorial Fund for Cancer Research, Inc.

Received for publication July 2, 1954.

pharyngeal wall, "piriform sinus," in selected cases on the base of the tongue, or in extensive cases of cancer of the extrinsic larynx. (See Fig. 1.) Sixteen patients were treated in this fashion without a death.

RESULTS OF TREATMENT BY MEANS OTHER THAN SURGERY

In the past the main reliance for therapy of tumors arising in this area has been upon radiation therapy. Regardless of the difficulties in classification mentioned previously, it is apparent to even the casual observer that despite the tremendous amount of labor and effort which has been expended upon this problem, the results have not been brilliant. There are several factors which militate against successful results in the treatment of cancer in this area. The inaccessibility of the hypopharynx to visual detection or palpation of tumors is a serious drawback to early diagnosis. The hypopharynx is a "silent area" where no warning symptoms such as dysphagia, dyspnea, or hoarseness appear until the growth has attained an advanced stage. In about one-half to two-thirds of the patients the first symptoms is a cervical metastasis. The head start which these tumors attain prior to diagnosis can be appreciated by the fact that the actual diameters of the tumor as measured on sixteen surgical specimens following removal ranged from 3.4 cm. to 5.6 cm. and the average area of open ulceration was 10.8 sq. cm.



A. *B.* *C.* *D.*

Fig. 1.—Types of primary tumors suitable for described operative procedure. *A*, Primary carcinoma—base of tongue, spread to adjacent pharyngeal wall and larynx. *B*, Primary carcinoma—base of epiglottis with spread to base of tongue. *C*, Primary carcinoma—lateral pharyngeal wall with spread to larynx. *D*, Primary carcinoma—extrinsic larynx, spread to pharyngeal wall.

Just as the combined neck and jaw resection is applicable to cancers arising in the floor of the mouth, jaw, tonsil, tongue, and so forth, the combined neck resection, total laryngectomy, and pharyngectomy can be used with a variety of primary growths.

The frequent invasion of the cartilagenous portions of the larynx with cancer produces complications that work against a successful result with irradiation therapy, and the morbidity following therapy in such instances is sufficiently severe as to sometimes make one doubt that even the term "palliation" can be fairly employed. The salvage rate achieved by x-ray therapy

is about the same in England, Sweden, France, Finland, Germany, Ireland, and Norway. (See Table I.) Baclesse[7] stated that the prognosis is slightly more favorable when the lesion is limited to the upper portion of the hypopharynx in distinction to those growths located lower down. Of 152 patients treated at the Curie Foundation with irradiation therapy and in whom the tumor was located in the region of the piriform sinus or what Baclesse referred to as "the lowermost areas of the hypopharynx," he was able to salvage only two patients with this mode of therapy.

The switch by our group to surgery as the main reliance for therapy in this group of tumors in preference to radiation therapy appears justified on the basis of the unanimously poor results achieved with x-ray treatment over the past thirty to forty years. Dr. Hayes Martin at the Head and Neck Clinic at Memorial Hospital in New York City stated that the 12 per cent cure rate (achieved there by radiation therapy) had more than doubled (30 per cent) following a change in that clinic from radiation therapy to radical surgery via laryngectomy and laryngopharyngectomy combined with neck dissection wherever indicated.[11] We are in no position at this time to present a significantly large series of patients with long-term end results to support this decision. We are reporting on another method of attack on the problem which seems justified only by the uniformly disappointing results achieved by all other methods of treatment.

TABLE I. RESULTS OF X-RAY TREATMENT OF CANCER OF HYPOPHARYNX (AFTER JACOBSSON,[13] ACTA RADIOL. 35: 1, 1951)

COUNTRY	NO. CASES	% 5-YR. CURES
England (Cade, 1949)	44	7
Finland (Sipila, 1949)	172	8
France (Coutard-Baclesse, 1949)	425	6
Germany (Glauner, 1949)	112	3
Ireland (Douglas, 1950)	77	6.5
Norway (Rennaes, 1949)	84	7
Sweden (Jacobsson, 1950)	84	14
London-Royal Cancer Hospital (Lederman, 1951)	162	10

MORBIDITY OF SURGICAL ATTACK

Acceptance of surgical attack upon these tumors practically always implies a willingness to sacrifice the larynx. There may be a rare occasion where the growth on the pharyngeal wall is discovered at such an early stage that wide removal without sacrifice of the larynx is possible. Unfortunately these cases are all too rare. Loss of the larynx is admittedly a difficult thing to accept, but is presumably preferable to dying from cancer. It must also be appreciated that by the time the diagnosis of cancer in this area is made, the tumor is well on its way to destroying the larynx anyway. It should not be necessary to state that unless the tumor is controlled the larynx will eventually be totally destroyed in every case.

Treatment of these lesions with irradiation carries with it the rosy dream of eradication of the tumor with preservation of the function of the larynx.

We have seen previously, however, that this dream is seldom realized. The concept of the word "larynx" implies a functioning organ as well as an anatomic structure. If the cords are destroyed, or the intrinsic musculature invaded by tumor so that no motion is present, or if the airway is occluded and the cartilagenous structures are eaten away by a mixture of necrosis, infection, and tumor, the structure is no longer fully worthy of the term "larynx" any more than a gangrenous limb that will no longer bear weight and is threatening the patient's life by infection and sepsis is fully worthy of the term "leg." It has been our experience that no patient who has had the opportunity of reviewing the entire picture has refused to accept this operation. The degree of morbidity following discharge from the hospital is just about the same as that resulting in a patient who has had a total laryngectomy. That is, the additional removal of the lymph nodes of the neck and adjacent portions of the pharyngeal wall or base of tongue has not resulted in an increase in morbidity over that which incurs in a patient suffering from a simple total laryngectomy.

CONTRAINDICATIONS TO SURGICAL ATTACK

Cancer of the hypopharynx appears to have its peak incidence among patients in the middle and latter decades of life. The appearance of associated disease such as diabetes, hypertension, and cardiovascular disease in all of its various forms may be expected to occur in a significant proportion of these patients. None of these complications have been considered by us to be a contraindication to surgical attack on the problem. An effort is made to get the patient in the best possible condition and then proceed with the operation. To abandon the operation because of the presence of associated complicating factors appears totally unjustified because of the lethal nature of the primary disease. Age, by itself, is no contraindication either. Three of our patients were above 70 years of age when operated upon, and the ability of aged persons to withstand extensive surgical procedures on the peripheral portions of their body is now so well recognized that it needs no further comment. The soundness of our ideas appears to be borne out by the fact that we have had no mortality in any of our cases.

One cannot attend scientific sessions or read reports pertaining to this subject without hearing someone suggest the idea that radiation therapy should be tried first and then, if it fails, resort to surgery should be planned. This is based on the concept that the patient should be given a preliminary chance to preserve a vital organ (larynx) even though the chance may be only slight. The complementary thought is then expressed that in the event the radiation fails, the surgery can then be tried without any increased difficulty and that nothing has been lost by the delay occasioned by direction of ionizing energy to the tissues.

Superficially this may appear to be a reasonable point of view. In actuality, however, such a plan of attack has turned out to be a triumph of naïveté. To handicap the irradiation therapist by forcing him to bear in mind the dual objectives of trying to eradicate a very extensive and difficult cancer and at

the same time spare from excessive exposure to x-ray the tissues that must ultimately be relied upon for healing is not only unfair but in our opinion is actually impossible to achieve. The creation of such a large wound as results following a radical neck dissection, removal of the larynx and a portion of the associated pharyngeal wall or base of the tongue, taxes the healing capacity of the human body to its fullest degree. With careful surgical technique, antibiotics, blood, and modern anesthesia, the patients appear to be able to meet this challenge. Superimposition of the additional handicap of a diminished blood supply to the tissues produced by previous x-ray therapy is incompatible with the success of this surgical procedure. It is also fair to state in this connection that to expect a radiologist to be able to carry out thorough and adequate therapy in a surgical field which has been scarred and deformed by previous operation is equally impractical. In brief, then, this operation appears to us to be contraindicated only when the patient directly refuses to accept the procedure, when in the opinion of the operating surgeon the disease is so extensive that even with this radical surgical attack a successful result carries with it no promise of success, or when previous x-ray therapy has been given.

PREOPERATIVE PREPARATION

No particular measures other than those usually employed in preparing a patient for a major surgical procedure are required. If the patient has some associated disease, such as diabetes or diminished cardiovascular reserves, an effort is made to put the patient in the best condition possible prior to subjecting him to the additional strain of the operative procedure. Suitable sedatives are given on the evening before the operation and in the hours immediately prior to the time when the patient is taken to the operating room. Blood volume studies have indicated that a replacement of about 1,500 c.c. of whole blood given during the course of the operation will prevent shock and leave the patient with sufficient red cell volume during the convalescent period to ensure good healing and return of strength.

TECHNIQUE OF OPERATIVE PROCEDURE

Preservation of an adequate airway must be assured. If the larynx itself is not extensively involved with tumor it is more convenient to pass an endotracheal tube in the usual way through the upper respiratory passages into the trachea. In the event that the lumen of the larynx has been narrowed by encroachment with the tumor, it is safer to perform a tracheostomy as the preliminary step and connect the tracheostomy tube with the anesthesia machine.

Once the airway has been established, the patient is draped in the usual fashion for head and neck operations and the actual operative procedure is begun. The first step consists of a radical neck dissection which is carried out on the side of greatest tumor involvement. The neck dissection is done regardless of whether there is clinical evidence of cervical metastases or not. The techniques of radical neck dissection have been described elsewhere

(Martin[4]) and will not be repeated here. In cancer surgery carried out anywhere in the body the general plan of attack is to start at some area beyond the field of involvement and to work from the periphery toward the primary tumor. The skin incisions (Fig. 2) are planned in such a way as to permit the permanent tracheostomy to be established in the midline of the medial flap. The potentially cancerous contents of the neck are mobilized in the course of the radical neck dissection, worked centrally, and left attached to the larynx in an effort to follow the principles of en bloc dissection (Fig. 3).

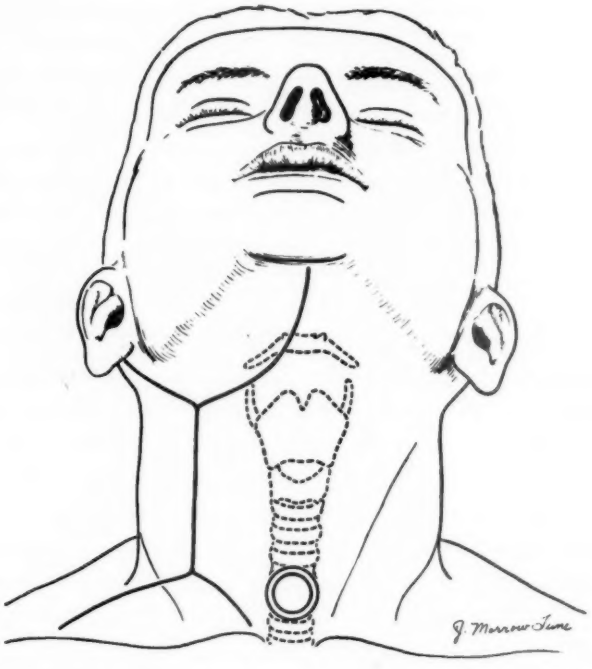


Fig. 2.—Plan of skin incision and tracheostomy.

At the conclusion of this phase, the uninvolved side of the larynx and adjacent pharyngeal wall are exposed. The isthmus of the thyroid gland is divided and the trachea is skeletonized. Preparations are now made to enter the pharynx directly and this is done through the uninvolved pharyngeal wall on the side opposite to the primary tumor (Fig. 4). This step is important inasmuch as it helps prevent the operator from inadvertently cutting through tumor tissue while attempting to enter the pharynx blindly on the involved side. With the opening into the pharynx, direct inspection of the tumor becomes possible and the dissection then proceeds around the primary tumor leaving a margin of 1 cm. of uninvolved pharyngeal mucosa on all sides of the growth.

Upon completion of this step, transection of the trachea is then carried out. If the anesthesia has been carried up to this point with an endotracheal tube passed through the upper respiratory passages, this must now be withdrawn and inserted into the tracheal stump through which anesthesia control is maintained during the residual portions of the operation (Fig. 5).

Closure of the pharyngeal defect is now begun. Atraumatic 000 chromic catgut sutures are used. The scheme of closure must be varied to fit the pattern of the defect resulting following removal of the tumor. This obviously will vary depending on the extent and location of the primary tumor, and considerable ingenuity is required to achieve a successful closure. In general, the mucosa must be approximated without too much tension and, most important of all, maximum use should be made of the adjacent soft tissues to buttress this mucosal suture line if fistula formation is to be held to a minimum. Stricture formation has not been a problem in our cases. In some instances the lumen of the reconstructed esophagus is hardly greater than the

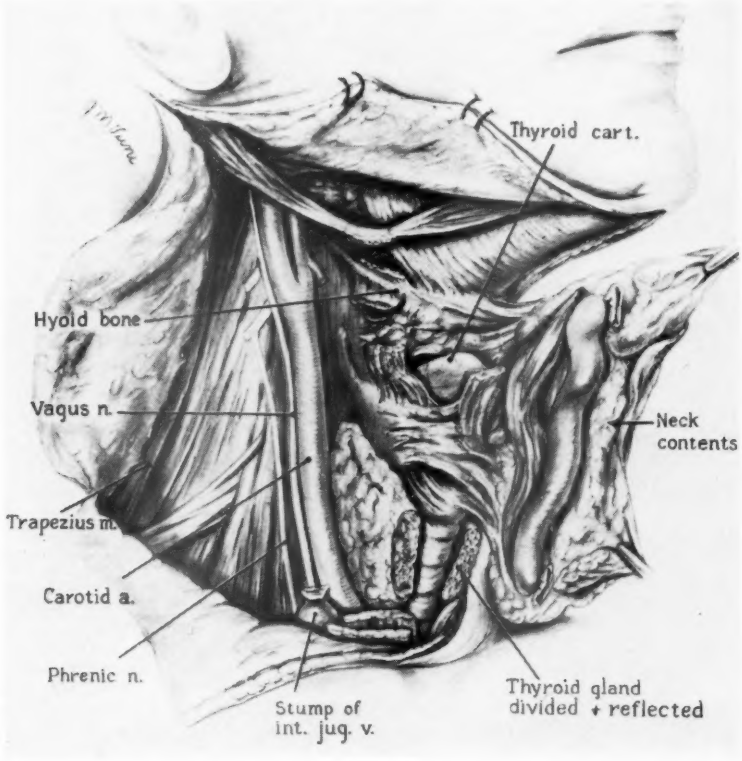


Fig. 3.—A radical neck dissection on side where bulk of tumor is located is done first. Neck contents are worked centrally toward primary growth and left attached to larynx.

diameter of the index finger. X-ray studies with barium following this operation have revealed that although the lumen of the reconstructed esophagus may appear to be narrow at the time of the operative closure, some stretching of the remaining normal pharyngeal and esophageal walls can be counted upon to occur, and a good functional result may be expected. The skin flaps are then reapproximated and sutures are placed on the undersurface of these skin flaps to bring them into close approximation with the reconstructed pharyngeal wall so that any dead space is obliterated and the skin flap itself can serve as an additional support to this important line of repair.

A circular incision is then made in the medial flap and the stump of the trachea is pulled through this incision. It is anchored to the skin edges with individual fine silk sutures uniting mucosa of trachea to skin margin. If the trachea has been cut across at an angle so as to leave a long posterior lip to the stump of the trachea, this approximation will be simplified. A No. 10 or 12 laryngectomy tube is then inserted into the newly constructed stoma.

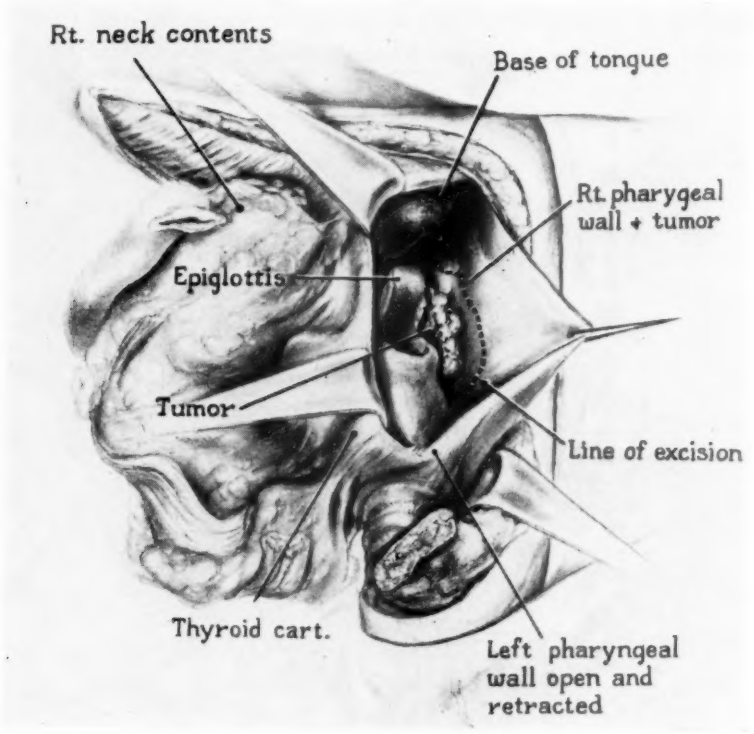


Fig. 4.—Pharynx is opened on side not involved. This permits direct inspection of tumor and prevents cutting through diseased area. (Endotracheal tube not shown.)

POSTOPERATIVE CARE AND COMPLICATIONS

Feeding.—The feeding of the patient during the postoperative phase will be simplified if an ordinary urethral catheter is placed through the nose of the patient and directed through the pharyngeal defect by the operator into the lower esophagus. The possibility of the tip of the catheter pushing through the mucosal suture repair exists if this is deferred until the patient has been returned to the wards. If a short catheter is used, a wad of adhesive tape should be wrapped around the end of the catheter protruding from the nose to prevent its slipping inadvertently through the nose and into the stomach.

Feeding can then be begun the next day through this tube. Starting off with 100 c.c. or so of water, tea, and other clear fluids, the patient may quickly be worked up to a more nutritious diet in a matter of a few days'

time. Despite the advantages in the past few years resulting from the introduction of various types of parenteral fluids containing increased caloric values, there is still no equal for the patient's own gastrointestinal tract when this is possible. The theoretical objection sometimes voiced to the effect that an indwelling nasal catheter compromises the healing of an esophageal anastomosis or suture line has not been a problem to us. With the application of the described scheme of nutrition during the convalescent period, patients usually will not lose more than four to five pounds in the course of this operation.

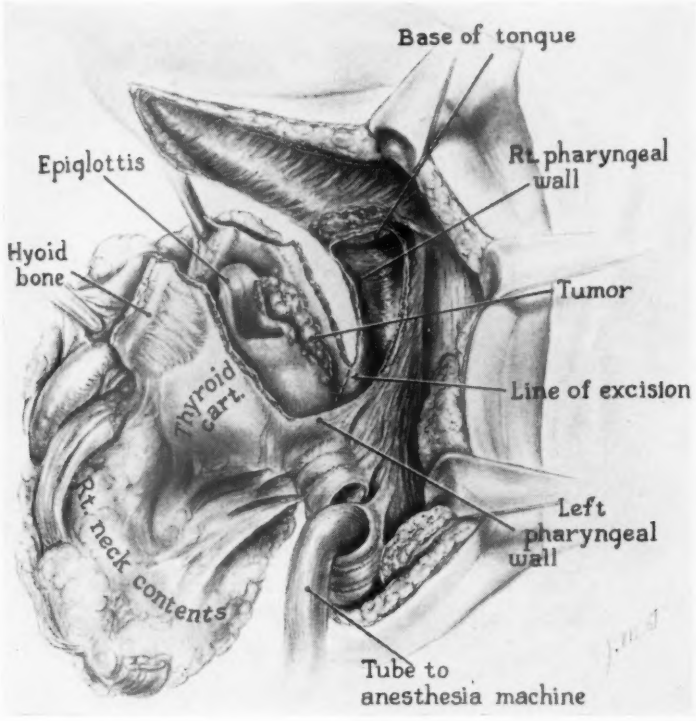


Fig. 5.—Larynx is sacrificed, preserving investing mucosa except where it approaches tumor. Trachea was divided preparatory to lifting out entire specimen.

Infection.—In view of the frequent association of necrosis of a tumor with its attendant bacterial flora it is not surprising that a certain degree of infection can be anticipated in all cases. It is a tribute to the effectiveness of modern antibiotic therapy that the patients master this infection and reach normal temperature levels within seventy-two hours postoperatively. Some degree of induration and swelling may be expected to exist for several weeks. No need for the continuance of antibiotics has existed beyond a twelve-day period.

Fistula Formation.—Fistula formation occurred in approximately one-third of the cases. The extent of the fistula depends to some degree on the size of the defect created by removal of the tumor and the resultant difficulty in attaining a primary closure. Its existence has not been a major problem

in any of our cases. The treatment consists of maintenance of feeding via the nasal catheter and the withholding of food taken through normal channels. We have not objected to the ingestion of clear water in the presence of a fistula, feeling that the water lost through the fistulous tract serves to irrigate

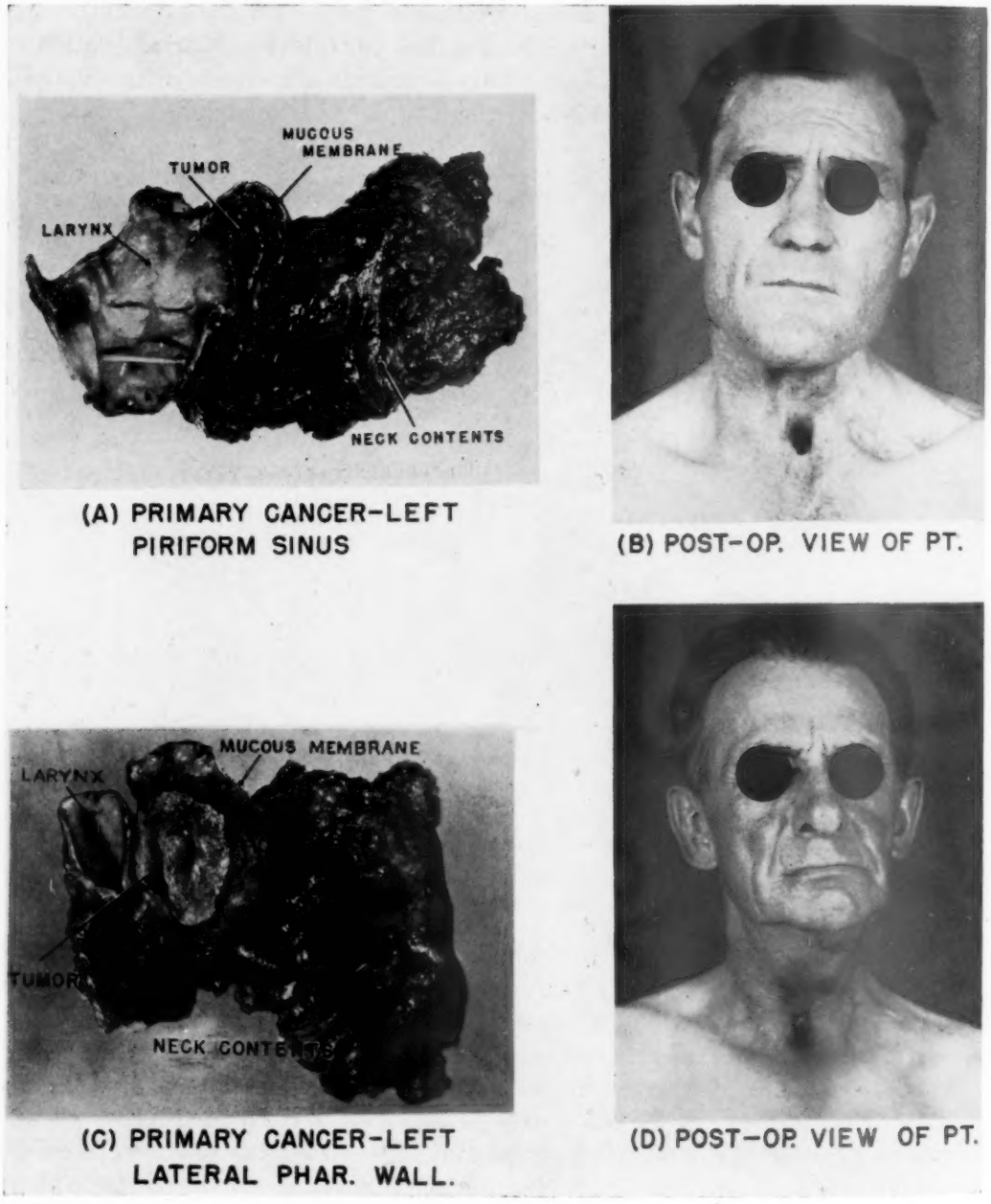
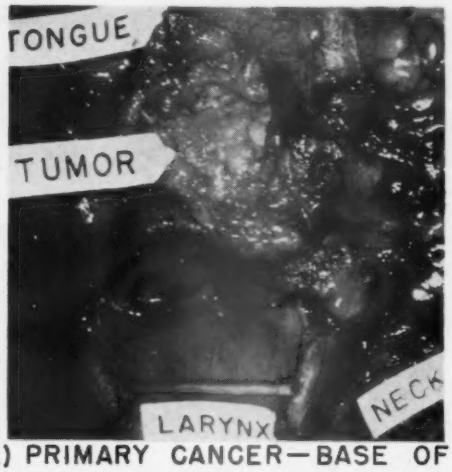


Fig. 6.

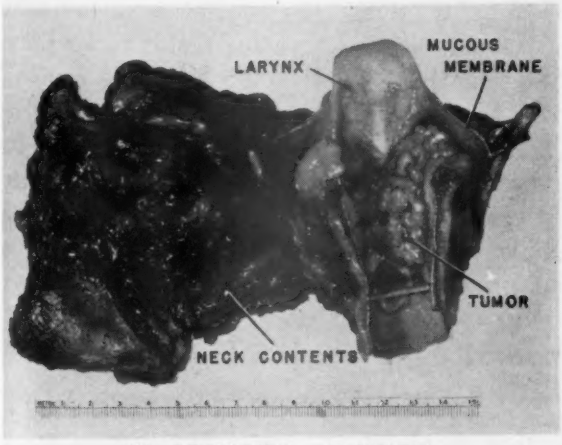
Figs. 6 and 7.—Four main varieties of cancer suitable for treatment with this operation. Functional result parallels that of simple total laryngectomy. (Neck dissection in specimen *G* carried out on right side although primary tumor was largely on the left. A crossed cervical metastasis was present preoperatively and the left side of the neck was clinically negative.)

the defect and does no harm. The same thing cannot be said to apply for milk and food particles which may collect in the recesses of the fistulous tract, which may serve as a nidus of infection. The fistulas have closed in every case without any further operative intervention, and their duration ranged from six to twenty-two days.



(E) PRIMARY CANCER—BASE OF TONGUE EXTENDING TO LARYNX

(F) POST-OP. VIEW OF PT.



(G) PRIMARY CANCER—EXTRINSIC LARYNX

(H) POST-OP VIEW OF PT.

Fig. 7. (*For legend see opposite page.*)

Hemorrhage.—No case of hemorrhage has occurred in the postoperative period. When hemorrhage has appeared in the months following the operation, it has been found to be associated with recurrence of tumor and has provided the actual mode of exodus in some of our failures.

Stricture.—Despite the narrowing subsequent to closure of the pharyngeal defects, no functional disturbances have resulted. Again, when this finding appears months following the operation it has proved in each case to be due to recurrence of tumor. No cases requiring esophageal dilatation have as yet occurred.

Chylous Accumulations.—In rare instances, particularly when the left side of the neck is operated upon, the thoracic duct may be opened. If this is recognized at the time of the operation it can be easily handled by the application of several transfixion sutures. In the event of failure of recognition, the classical appearance of the milky white material will appear in the drainage. Tamponade with Gelfoam or some suitable substitute in the supraclavicular fossa through the drainage aperture and pressure dressings will care for this in a matter of days.

Speech Rehabilitation.—No handicap to the subsequent development of esophageal speech has been encountered.

SUMMARY AND CONCLUSION

The problems atttendant to obtaining a cure in patients suffering from cancer developing in the general region of the hypopharynx have been discussed. The hypopharynx is a "silent area" and tumors developing in this region are likely to have reached an advanced stage before they are diagnosed by the physician, and the patient is referred for definitive therapy. The average area of open ulcerated tumor measured on sixteen surgical specimens was found to be 10.8 sq. cm.

The uniformly poor results obtained by previous methods of therapy are documented. When a method has been tried as many times as irradiation has been in the treatment of these lesions and a successful result is achieved so rarely, it is time to consider other methods of attack. Surgical removal of these lesions has been perfected to the point where a reasonable morbidity and mortality can be expected. The functional end result with this extensive operative is no greater than that resulting from simple total laryngectomy (Figs. 6 and 7). The technique of operation with a discussion of the postoperative problems is outlined. The series is too small to demonstrate any unequivocal improvement in end results, but preliminary studies indicate an improvement.

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THE USE OF CELLULOSE SPONGES IN SURGERY

Further Observations

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(From the Department of Surgery, Buffalo General Hospital, and University of Buffalo School of Medicine)

IN 1953 we reported our preliminary observations on the use of a new type of surgical sponge made of cellulose recovered from wood.* Our experience with this product has been extended, and the senior author has used it routinely as a substitute for the usual gauze surgical sponge for the past year.

The chief advantage of this type of sponge is that it can be quickly rinsed by the scrub nurse and returned to the operative field when it becomes impregnated with blood. Because of this the number of cellulose sponges required for most operations is much less than the number of gauze sponges required for the same operation. The cost of sponges is therefore greatly decreased. Additional savings also accrue from the smaller storage space required in stock rooms. Among other advantages are the following: Sponge counts are more quickly and more accurately made with a minimum number of sponges. The repeated use of a few sponges with periodic rinsings in a sterile solution at the operating table affords an excellent method of measuring blood loss.

Minor changes in the manufacturing process have enabled the distributors† of this product to furnish now an improved sponge which is white in color, thinner, less resilient, and with a smoother surface texture. A typical x-ray pattern due to an even dispersion of particles of barium sulfate has been maintained. The present sponge has an average total absorbency for water of 1,000 per cent by weight. The average tensile strength is 90 pounds per square inch in the moist state.

Animal Experiments.‡—Experiments, additional to those reported in our preliminary communication and involving the implantation of this sponge material in dogs for periods of time up to six months, have been carried out.

Twenty-one healthy mongrel dogs were used. Under Nembutal sodium anesthesia, these animals were operated upon with the usual aseptic technique, and sterile samples of the sponge one and one-half inches square and one-eighth inch thick were implanted in various locations within their tissues. All operative incisions were closed in layers with fine cotton sutures. Similar-sized pieces of the usual gauze surgical sponges were similarly implanted in similar

Received for publication, June 29, 1954.

*Paine, J. R., and Egan, R. W.: The Use of Cellulose Sponges in Surgery. A Preliminary Report, Surgery 34: 803-809 (Nov.) 1953.

†O-Cel-O Division of General Mills, Inc., Buffalo, New York.

‡These experiments were carried out by Dr. M. Lapp and Dr. D. Kelley of the Department of Surgery of the Buffalo General Hospital.

animals for controls. All these animals remained in good health without detectable symptoms referable to the implanted material until sacrificed at a specific time. After sacrifice of the animal the implanted material with the surrounding tissues was excised en bloc, fixed in formalin, and sectioned for histologic study.

Table I summarizes these experiments. Figs. 1 and 2 are photomicrographs which show the tissue reaction provoked by the implanted material. We have interpreted these photographs as showing no detectable difference in the tissue reaction produced by the cellulose sponge and the gauze sponge. In both instances the magnitude of the reaction seems to be directly proportional to the length of time of implantation. No difference was noted in the reaction provoked by the unwashed cellulose sponge as compared to that resulting from the same material thoroughly washed in sterile water prior to its implantation.

TABLE I. IMPLANTATION OF SPONGE MATERIAL IN DOGS

	INTERVAL BETWEEN IMPLANTATION AND SACRIFICE								
	1-2 WEEKS		3-4 WEEKS		4-5 WEEKS		5-6 MONTHS		
LOCATION OF IMPLANT	DRY UNWASHED CELLULOSE SPONGE	WET WASHED CELLULOSE SPONGE	DRY UNWASHED CELLULOSE SPONGE	WET WASHED CELLULOSE SPONGE	DRY UNWASHED CELLULOSE SPONGE	WET WASHED CELLULOSE SPONGE	DRY UNWASHED CELLULOSE SPONGE	WET WASHED CELLULOSE SPONGE	DRY COTTON GAUZE
Peritoneal cavity	3 dogs	1 dog	1 dog	2 dogs	3 dogs	2 dogs	3 dogs	2 dogs	2 dogs
Pleural cavity			1 dog	1 dog	2 dogs	2 dogs	1 dog		2 dogs
Subcutaneous tissue	2 dogs		2 dogs		3 dogs				
Brain					1 dog	1 dog			2 dogs

*Bacteriologic Study.**—If any sponge is to be used repeatedly throughout an operation, even in the so-called "clean" case, the probability immediately arises that such a practice will increase the likelihood of postoperative infection by distributing more widely the stray bacteria encountered in body tissues or contaminating the sterile field from other sources. It is apparent that, unless a bactericidal solution is used to rinse the sponges, any contamination from microorganisms, pathogens or nonpathogens, originating in the patient or from other sources, will be carried back and forth between the sponge rinse solution and the operative site by the sponges.

In an effort to determine how much risk might be involved in the repeated use of a rinsed sponge during operation and to determine whether or not the use of an aqueous solution of Zephiran chloride 1:5,000 as the rinse solution would obviate this risk, several carefully controlled experiments have been carried out in the operating room. Cultures were taken of the rinse solution during the course of five operations using sterile water to rinse the sponges

*These observations were made with the help of Dr. J. Stage and the Department of Bacteriology of the Buffalo General Hospital.

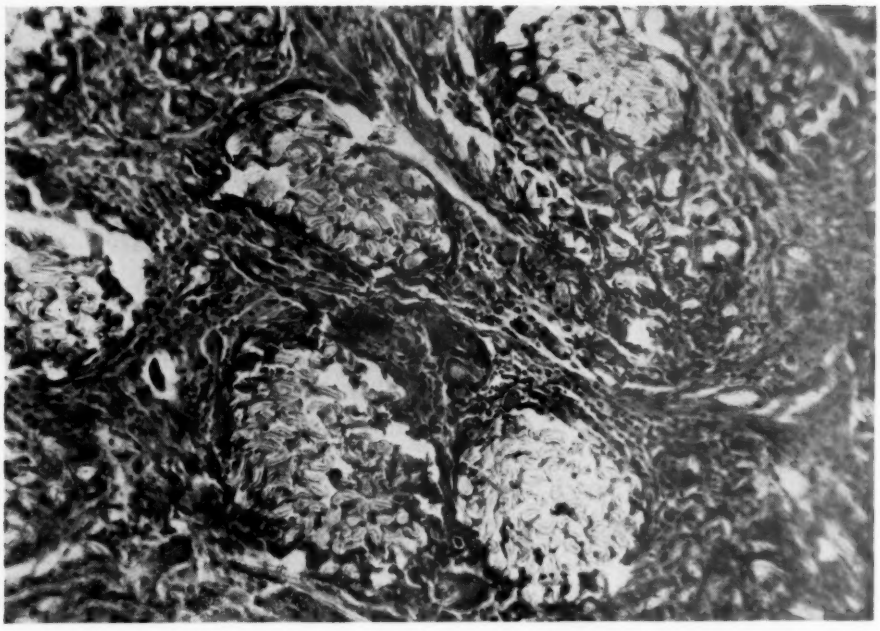

Fig. 1.—Microphotograph of gauze surgical sponge implanted in a dog for six months. Extensive growth of fibrous tissue about and between the threads of the gauze is evident. There is an associated moderate infiltration of round cells, both lymphocytes and polymorphonuclear leukocytes.

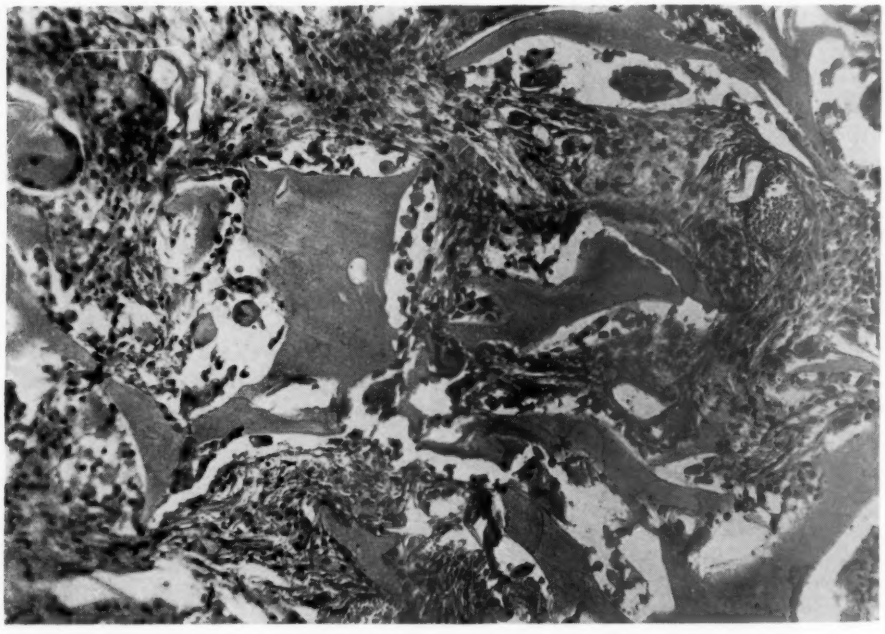

Fig. 2.—Microphotograph of cellulose sponge implanted in a dog for six months. There is extensive ingrowth of fibrous tissue into the interstices of the sponge, but all spaces are not filled. The inflammatory reaction is moderate, certainly no greater than that associated with implanted gauze.

and during the course of three operations using an aqueous solution of Zephiran chloride 1:5,000.

In Table II the results of these observations have been summarized. The details of two of these cases are given later in the article.

TABLE II. BACTERIOLOGIC STUDIES OF CELLULOSE SPONGES USED WITH REPEATED RINSINGS DURING THE COURSE OF VARIOUS SURGICAL OPERATIONS

OPERATION	DURATION OF OPERATION	SPONGES PRIOR TO OPERATION		SPONGES AFTER OPERATION		RINSE SOLUTION AFTER OPERATION	CONTROL RINSE SOLUTION
				A			
		Sterile	*Contaminated*	*Sterile*	*Contaminated*	*Water*	*Water*
1. Pneumonectomy	4 hr.	3	0	1	2	Contaminated	Sterile
2. Excision of mixed tumor of parotid	2 hr.	3	0	2	1	Contaminated	Sterile
3. Inguinal herniorrhaphy	1 hr., 5 min.	3	0	3	0	Sterile	Sterile
4. Ventral herniorrhaphy	2 hr., 15 min.	3	0	1	2	Contaminated	Sterile
5. Subtotal gastrectomy	4 hr., 10 min.	3	0	0	3	Contaminated	Sterile
				B			
		Sterile	*Contaminated*	*Sterile*	*Contaminated*	*Aqueous Zephiran Chloride Solution 1:5,000*	*Aqueous Zephiran Chloride Solution 1:5,000*
6. Subtotal gastrectomy	5 hr.	3	0	3	0	Sterile	Sterile
7. Exploratory thoracotomy	3 hr., 30 min.	3	0	3	0	Sterile	Sterile
8. Segmental resection of lung	3 hr., 40 min.	3	0	3	0	Sterile	Sterile

Operation No. 5 in Table II.—R. H.: Subtotal gastric resection for carcinoma of stomach with gastrojejunostomy employing a closed type of anastomosis.

Control rinse water: Sterile water standing in basin in corner of operating room.

Rinse water for sponges: Sterile water used to rinse blood from cellulose sponges during the operation.

8:20 A.M.: Specimens for culture taken prior to beginning of operation:
1. Control rinse water.
2. Sponge rinse water.
3. Portions of three cellulose sponges.

8:22 A.M.: Start of operation.

9:30 A.M.
10:30 A.M. } Specimens of control rinse water and sponge rinse water taken for culture.
11:30 A.M.

11:30 A.M. Swab of operative field taken for culture.

12:10 P.M. Operation completed. Specimens of control rinse water, sponge rinse water, and portions of three cellulose sponges used during the operation taken for culture.

Results of culture:

1. Cellulose sponges:
Before operation—no growth.
After operation—all yielded *Streptococcus viridans* and diphtheroids.

2. Swab of operative field during operation—*Str. viridans* and diphtheroids.
3. Specimens of control rinse water and sponge rinse water:

Prior to operation	*Control rinse water*	*Sponge rinse water*
8:20 A.M.	No growth	*Staphylococcus albus* hemolyticus coagulase negative and diphtheroids (approximately 3 colonies per c.c.)
9:30 A.M.	No growth	*Staph. albus* hemolyticus coagulase negative and diphtheroids (approximately 6 colonies per c.c.)
10:30 A.M.	Anaerobic staphylococcus (present in one of ten cultures)	Diphtheroids (approximately 6 colonies per c.c.)
11:30 A.M.	Anaerobic staphylococcus (present in one of ten cultures)	*Str. viridans* and diphtheroids (approximately 3 colonies per c.c.)
12:10 P.M. Operation finished	No growth	*Str. viridans.* Beta hemolytic streptococci and diphtheroids (approximately 200 colonies per c.c.)

Operation No. 6 in Table II.—C. S.: Subtotal gastric resection for obstructing duodenal ulcer with gastrojejunostomy employing a closed type of anastomosis.

Control rinse solution: Aqueous Zephiran solution 1:5,000 standing in basin in corner of operating room.

Rinse solution for sponges: Aqueous Zephiran solution 1:5,000 used to rinse blood from cellulose sponges during operation.

1:10 P.M.: Specimens for culture taken prior to beginning of operation.
1. Control rinse solution.
2. Rinse solution for sponges.
3. Portions of three cellulose sponges.

1:15 P.M.: Start of operation.

2:10 P.M., 3:10 P.M., 4:10 P.M.: Specimens of control rinse solution and rinse solution for sponges taken for culture.

4:30 P.M: Swab of operative field taken for culture.

4:50 P.M.: Operation completed. Specimens of control rinse solution and rinse solution for sponges and portions of three cellulose sponges used during the operation taken for culture.

Results of culture:

1. Cellulose sponges:
   Before operation—no growth.
   After operation—no growth.
2. Swab of operative field—no growth.
3. Specimens of control rinse solution and rinse solution for sponges:

Prior to operation	*Control rinse solution*	*Sponge rinse solution*
1:10 P.M.	No growth	No growth
2:10 P.M.	No growth	No growth
3:10 P.M.	No growth	No growth
4:10 P.M.	No growth	No growth
4:50 P.M. Operation finished	No growth	No growth

MEASUREMENT OF BLOOD LOSS

The cellulose sponge can be easily freed of any blood which it has absorbed by merely rinsing it in water or aqueous Zephiran chloride solution 1:5,000. Both of these solutions hemolyze the red blood cells, and the rinse solution becomes a solution of hemoglobin which increases in concentration as more and more blood is rinsed out of the sponges. Normal saline solution

cannot be used to rinse the sponges since it does not hemolyze the red blood cells but allows clots to form in the interstices of the sponge and in the solution itself.

Measurement of the amount of hemoglobin which has collected in the rinse solution and that contained in the blood in the suction bottles, if an aspirating tube and tip have been employed during the operation, affords an easy and accurate method of determining blood loss at the end of a surgical procedure or at any time during the operation if such is required. Because of the results of the bacteriologic observations reported here, we have used aqueous Zephiran chloride solution 1:5,000 routinely for the past six months for rinsing the sponges. Control measurements have shown that this chemical compound does not affect the accuracy of hemoglobin determinations made with the Evelyn colorimeter.

The method we have used is as follows: The contents of the suction bottle, which must be completely hemolyzed, are thoroughly mixed with the contents of the sponge rinse basin, and the total quantity is measured. A sample of this mixture is taken and its hemoglobin content measured with the Evelyn photoelectric colorimeter. Having obtained this value and knowing the patient's preoperative hemoglobin level, the calculation of the blood loss is easily determined as in the following example:

Calculation of Blood Loss:

If the total volume of sponge rinse solution and contents of suction bottle =2,800 c.c.,

If the hemoglobin content of this mixture = 1.8 Gm. per 100 c.c.,

The total amount of hemoglobin lost by the patient = 1.8 Gm. × 28 = 50.4 Gm.

If the patient's preoperative blood hemoglobin content = 12 Gm. per 100 c.c.,

The total blood volume loss by the patient = $\frac{50.4}{12} \times 100$ c.c. = 420 c.c.

In Table III a few operations are listed in which the blood loss was measured by the method described here. No attempt has been made to estimate or measure the quantity of blood absorbed by the wound towels and other surgical linen.

DISCUSSION

In our previous report it was indicated that the use of cellulose sponges as a substitute for gauze sponges had sufficient advantages to ensure, probably, in time, a place for this material in the surgical armamentarium. More extensive experience has confirmed this impression. Recent improvements in the manufacturing process have resulted in a pure white sponge of fine texture which is more easily handled and more adaptable to small spaces. Implantation experiments in which the cellulose sponge has been left in animals for as long as six months indicate that the inadvertent leaving of such a sponge in a patient will certainly not be a trivial matter, but that the results to be expected from such an accident will be no worse than those resulting from a gauze sponge of the same size. In this respect, the great advantage of the cellulose

sponge lies in the fact that so few sponges have to be used, despite the length or magnitude of the operation, that it is much easier to keep track of them. As a result, accurate sponge counts are more quickly obtained with much less effort and confusion. The incorporation of flecks of barium sulfate as an integral part of the sponge material ensures its ready location and identification on a roentgenogram if this becomes necessary. An extension of the observations made on the tissue reaction to the sponge material implanted in the tissues of dogs has confirmed the impression previously reported that this cellulose material stimulates a foreign-body reaction in the surrounding tissues which is practically identical to that produced by the implantation of comparable amounts of cotton gauze.

TABLE III. BLOOD LOSS DURING OPERATION DETERMINED BY MEASURING HEMOGLOBIN CONTENT OF SPONGE RINSE SOLUTION AND CONTENTS OF SUCTION BOTTLE

1. Exploratory laparotomy	80 c.c.
2. Exploratory laparotomy	134 c.c.
3. Subtotal gastric resection	700 c.c.
4. Subtotal gastric resection	140 c.c.
5. Total gastric resection	716 c.c.
6. Cholecystojejunostomy	54 c.c.
7. Cholecystoduodenostomy with lysis of adhesions	489 c.c.
8. Cholecystectomy and choledochostomy	47 c.c.
9. Cholecystojejunostomy	110 c.c.
10. Cholecystectomy and choledochostomy	340 c.c.
11. Excision of pharyngoesophageal diverticulum	330 c.c.
12. Repair of recurrent diaphragmatic hernia	370 c.c.
13. Excision of pulmonary cyst	300 c.c.
14. Subtotal thyroidectomy	130 c.c.
15. Exploratory thoracotomy for carcinoma of lung	2,200 c.c.
16. Sigmoid resection	74 c.c.
17. Leg amputation	142 c.c.
18. Excision pharyngeal-esophageal diverticulum	145 c.c.
19. Excision esophageal diverticulum	24 c.c.
20. Subtotal thyroidectomy	255 c.c.
21. Esophageal resection—first and second stages	842 c.c.
22. Vagotomy and gastroenterostomy	172 c.c.
23. Excision esophageal diverticulum	25.5 c.c.

The clear-cut nature of the results of the bacteriologic cultures of the sponge rinse water or solution indicates that some bactericidal solution should be used. In four of five instances in which cultures were made, the rinse solution was found to be contaminated when sterile water was used for this purpose. Furthermore, it would appear that the degree of contamination increases with the increase in the length of the operation. It is apparent that any contamination of a sponge with microorganisms, pathogenic or nonpathogenic, originating from the patient or from any other source, will be widely distributed when the sponge is carried repeatedly back and forth between a rinse basin and the operative field if water is employed. Although not specifically tested, the use of normal saline solution instead of water for the purpose of rinsing the sponges would seem to be equally inappropriate from the standpoint of bacterial contamination. Moreover, saline solution cannot be used because it will not hemolyze the red blood cells but allows clotting to occur in the interstices of the sponge so that adequate rinsing is impossible.

As a solution of this problem of contamination, with its danger of postoperative infection, we have for several months now used an aqueous solution of Zephiran chloride 1:5,000 routinely as the rinse solution. This concentration was chosen arbitrarily since it has strong bactericidal properties and at the same time is well tolerated by the most delicate tissues. Other solutions with similar properties should serve the same purpose equally well.

Cultures have been made during the course of three operations, as indicated in Table II, in which aqueous Zephiran chloride was used as the rinse solution. No contamination was noted in any of these cases. Our observations of other patients in whom this technique was employed, but no cultures made, have not revealed any instances of infection which could reasonably be blamed on this cause.

It would certainly seem to be highly undesirable to continue to use a sponge which has obviously become grossly contaminated with pus, bronchial secretions, or the contents of the gastrointestinal tract. Cellulose sponges so contaminated should be immediately discarded just as gauze sponges are. In the experiments and experience here reported, great care has been taken to follow this technique.

In those patients operated upon for cancer, the repeated use of rinsed sponges may be criticized because of the theoretical danger of the transplantation of cancer cells to other parts of the operative field. In those cases in which malignant tissue is transected during an operation, such criticism would appear to be valid. From the practical standpoint, no observations have been made which would substantiate this criticism.

The measurement of blood loss incident to surgery made by measuring the hemoglobin content of the sponge rinse solution and that in the suction bottle is a much more convenient method than any other we are acquainted with. No special apparatus is required other than the Evelyn photoelectric colorimeter, which is now standard equipment in most hospitals. The time required is ten to fifteen minutes. Since blood loss during an operation varies so widely from patient to patient, and with different surgeons, it is impossible to compare the accuracy of one method of measurement over another by any simple experiment. After considering the various factors involved, however, this method appears to be the most accurate of any method yet suggested. It is admitted that no account is taken of that blood which is absorbed by the wound towels, drapes, and gowns. If this is desired the amount involved must be estimated. In a few instances large sheets of the cellulose material have been used as wound towels and these have been rinsed at the completion of the operation in an effort to increase the accurary of the blood loss measurement. Further experience will be required, however, before one can say whether or not this will be a practical idea.

SUMMARY

Further experiences with the use of a manufactured cellulose sponge as a substitute for the usual surgical gauze sponge have been recounted. An

improved manufactured sponge is now available which is white in color, less resilient, and with a smoother surface texture. Portions of the cellulose material were implanted in twenty dogs for as long as six months. There appeared to be no detectable difference in the tissue reaction produced by the cellulose sponge and the gauze sponge.

The cellulose sponges and the sponge rinse solution were cultured repeatedly during the course of eight operations. In four of five operations in which water was employed to rinse the sponges, bacterial contamination was found. The amount of contamination appeared to increase with increase in the length of the operation. In three cases in which aqueous Zephiran solution was used to rinse the sponges, no bacterial contamination was noted.

Measurement of the hemoglobin content of the sponge rinse solution and the hemoglobin content of the contents of the suction bottle by means of the Evelyn colorimeter was found to be an easy and rapid method of estimating blood loss during surgery. Results obtained by this method in twenty-three representative operations are given.

PLEURAL DRAINAGE FOLLOWING PNEUMONECTOMY: DESCRIPTION OF APPARATUS

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ALTHOUGH drainage of the pleural cavity is not widely employed following pneumonectomy, few will deny that there are instances when the procedure may be of value. It may prove useful to place a catheter into the pleural cavity following pleural pneumonectomy or other procedures which might be followed by excessive effusion of fluid; also, following resection under thoracoplasty, when relatively small amounts of fluid in a restricted pleural space can cause dangerous shifting of the mediastinum. Moreover, drainage is a safeguard when bronchial leakage is considered a likely possibility. A dry hemithorax is also of value in preventing infection in the presence of tuberculosis or severe contamination with any other organisms.

One of the most widely voiced objections to the use of pleural drainage following pneumonectomy has been that it is difficult to maintain the mediastinum in the midline under such circumstances. This objection has been overcome, we believe, by the employment of the apparatus to be described. The successful use of a similar apparatus has been reported recently by Storey and Laforet.[1]

Fig. 1 is a diagram of the apparatus, which may be recognized as a modification of the type used in many institutions for controlled suction. A source of suction is not necessary. Three bottles are used. Bottle *A* is a reservoir for drainage fluid and is connected to the intercostal catheter (usually a No. 24 Fr. which has been placed in a dependent position). Bottle *B* controls the positive side of the pressures within the system, allowing the escape of air when the pressures exceed the degree represented by the distance of the submerged tube orifice from the surface of the water. Bottle *C* controls the negative side of the pressures within the system, allowing air to enter when the pressures fall below the degree represented by the distance of the submerged tube orifice from the surface of the water.

In conjunction with the use of the apparatus the following practices have been found of value. The lower orifice of the tube in bottle *B* is set 1 cm. below the surface of the water, and the lower orifice of the tube in bottle *C* is set 13 cm. below the water surface. The average of these two levels (that is, plus 1 and minus 13) is minus 6 cm. of water, which is the generally accepted normal mean intrapleural pressure during quiet breathing.

Received for publication July 13, 1954.

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The diaphragm is not paralyzed at the time of pneumonectomy for it is believed that the motion of both leaves of the diaphragm is important for the maintenance of maximum effective cough and ventilation. The patient is encouraged to lie either supine or on the operated side to provide better drainage and aeration of the remaining lung. Pleural drainage is usually terminated after twenty-four to forty-eight hours, for beyond this period there is usually a marked diminution in the rate of formation of fluid. Following removal of the intercostal catheter, it is usually not necessary to perform a thoracentesis as absorption of air tends to compensate for accumulation of fluid.

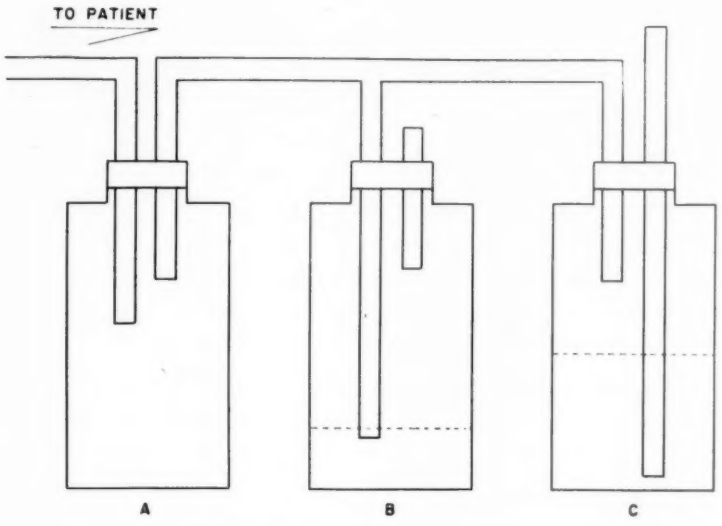


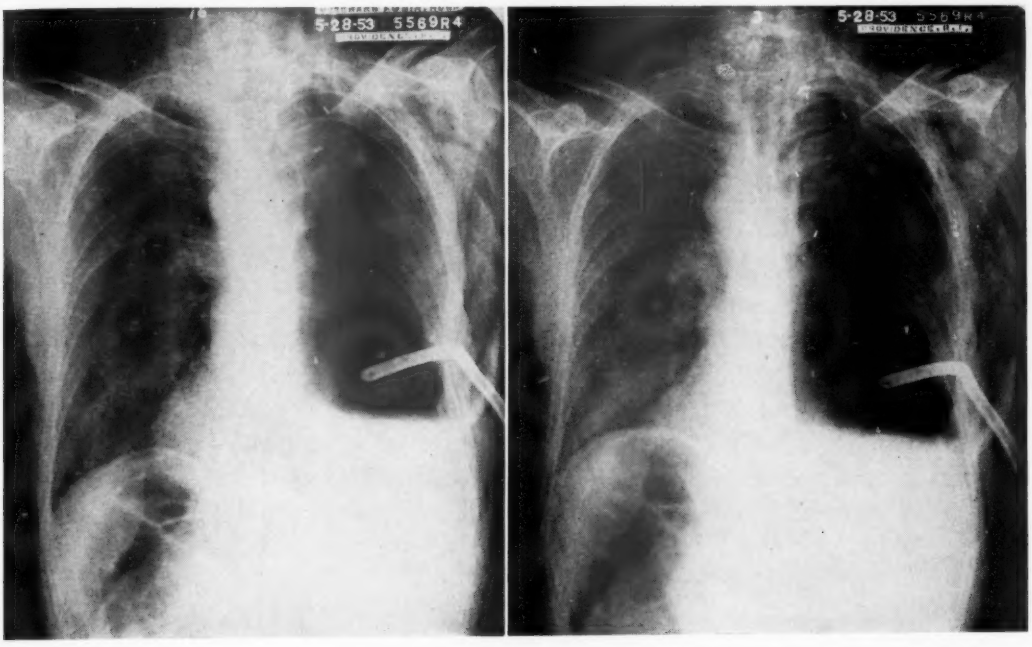
Fig. 1.—Diagram of apparatus.

DISCUSSION

Since the apparatus was designed and first utilized by one of us (D. V. P.) in the spring of 1951, it has been employed following twenty-six pneumonectomies. There were two early deaths in this series, neither of which could possibly have been attributable to the use of drainage. One patient failed to regain spontaneous respiration following termination of anesthesia. The other patient died of massive hemorrhage several hours after he had left the operating room. Both were elderly patients with bronchogenic carcinoma. Occasionally, subcutaneous emphysema occurred due to extravasation of air from the pleural cavity, but this complication was minimized by employing a tight pressure dressing over the thoracotomy wound. There were no other complications attributable to the use of the apparatus.

Various physiologic studies were undertaken. Inspiration and expiration x-ray films showed no appreciable change in the position of the mediastinum with the patient erect or supine (Fig. 2). X-ray films with the patient on the operated side revealed a degree of mediastinal shift comparable to that which occurs in the normal person (Fig. 3). Repeated careful observation of the

patients' pulses, respirations, and blood pressures failed to reveal any adverse effects which might be attributable to the use of the apparatus. There was no interference with the patients' ability to cough, as might have been expected



A. *B.*

Fig. 2.—Anteroposterior x-ray film taken on the first postoperative day in the upright position on inspiration (*A*) and expiration (*B*). Pneumonectomy, performed for tuberculosis, was largely extrapleural. At operation the mediastinum was considered of average mobility.

Fig. 3.—Anteroposterior x-ray film taken on the first postoperative day with patient on the right side. Note slight mediastinal shift due to gravity. There is a small amount of fluid present.

from the theoretical considerations reported by Howe.[2] Apparently the empty hemithorax with its intercostal tube was able to build up the transient high pressures necessary, much as would an old-fashioned bellows.

SUMMARY

An apparatus to be used in conjunction with pleural drainage following pneumonectomy is presented and discussed. The indications for and advantages of its use are cited.

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Case Reports

PNEUMATOSIS CYSTOIDES INTESTINALIS

Case Report of a Korean Man

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PNEUMATOSIS intestinalis is defined as an abnormal collection of gas in the walls of the intestine or its supporting structures. It has been reported under various descriptive titles: "gas cysts of the intestine," "intestinal emphysema," but "pneumatosis cystoides intestinalis" seems to be preferred. Although it was known to John Hunter, the first adequate description of a case in a human being is that of Bang in 1876.[1] The first report in the American literature was by Finney in 1908.[2] To our knowledge, the case forming the basis of this report represents the forty-fifth in the American literature and the fifth to be diagnosed preoperatively.[3]

CASE REPORT

A 33-year-old male laborer in the Korean Service Corps was admitted to the 171 Station Hospital on March 13, 1953, because of weakness, epigastric distress, and vomiting. He gave a history of recurrent epigastric pain and vomiting since age 16. These symptoms became worse during the five months prior to admission and were associated with diarrhea and a cramping pain. There was no history of hematemesis, melena, nocturnal pain, or specific food intolerance.

Physical examination revealed a thin, apprehensive Korean man with epigastric distress. Blood pressure was 124/76. The only abnormality noted was tenderness to deep pressure in the epigastrium.

Laboratory Findings.—The initial blood picture and urinalysis were normal. Total serum protein was 7.3 Gm. per cent, serum albumin 4.4 Gm. per cent, and serum globulin 2.9 Gm. per cent. Icterus index and cephalin flocculation were normal. Blood nonprotein nitrogen was 30 mg. per cent and serum carbon dioxide-combining power, 62 volumes per cent. Stools were repeatedly positive for the ova of *Ankylostoma duodenale* and *Trichuris trichiura.*

A chest roentgenogram showed a large area of translucency with small, archlike lines under the right diaphragm (Fig. 1). An upper gastrointestinal series demonstrated small bowel loops in the right subphrenic space. A cholecystogram was reported as negative except for "air under the right diaphragm."

Course.—In view of the roentgenographic findings without clinical evidence of a perforated viscus, a diagnosis of pneumatosis cystoides intestinalis was made by one of us (P. R. C.). At laparotomy (by H. M. W.) on April 11, 1953, several loops of upper jejunum were found matted together by fibrous adhesions between the right lobe of the liver and diaphragm (Fig. 2). A twelve-inch segment of upper jejunum contained innumerable subserosal gas cysts varying in diameter from a few millimeters to about

Received for publication April 22, 1954.

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5 cm. (Fig. 3). These changes did not extend beyond a point of apparent narrowing in the bowel lumen. Because of its localization and the possibility of intestinal obstruction, the involved segment of bowel was resected, and an end-to-end anastomosis was performed. Except for subserosal strands of scar tissue throughout the ileum and its mesentery, the remainder of the abdominal exploration was negative. The patient made an uneventful recovery and was asymptomatic upon discharge.

Pathologic report was pneumatosis cystoides intestinalis (intestinal emphysema) of the jejunum due to unknown cause, with associated acute and chronic inflammation, focal hemorrhage, and fibrosis.

Fig. 1.—Upright chest roentgenogram showing a large area of translucency with archlike lines under the right diaphragm.

DISCUSSION

Pathogenesis.—The exact mechanism by which emphysema is produced is not known. Of merely historical interest are the neoplastic[1, 2] and bacterial[4, 5] theories. The experimental production of gas cysts in hogs fed on polished rice[6] suggests the nutritional deficiency theory. In support of the latter, many observers have noted that pneumatosis cystoides intestinalis occurring in man is frequently associated with diseases producing nutritional disturbances.

At present it is generally agreed that this condition is best explained by the mechanical theory. This theory implies that gas from the intestinal lumen penetrates the bowel wall through gross or microscopic mucosal defects. Increased intraluminal pressure and hyperperistalsis may force gas from the bowel wall into the tissue spaces, probably through lymphatic channels.[7]

Fig. 2.—Gross appearance at laparotomy, showing extensive involvement with subserosal air cysts.

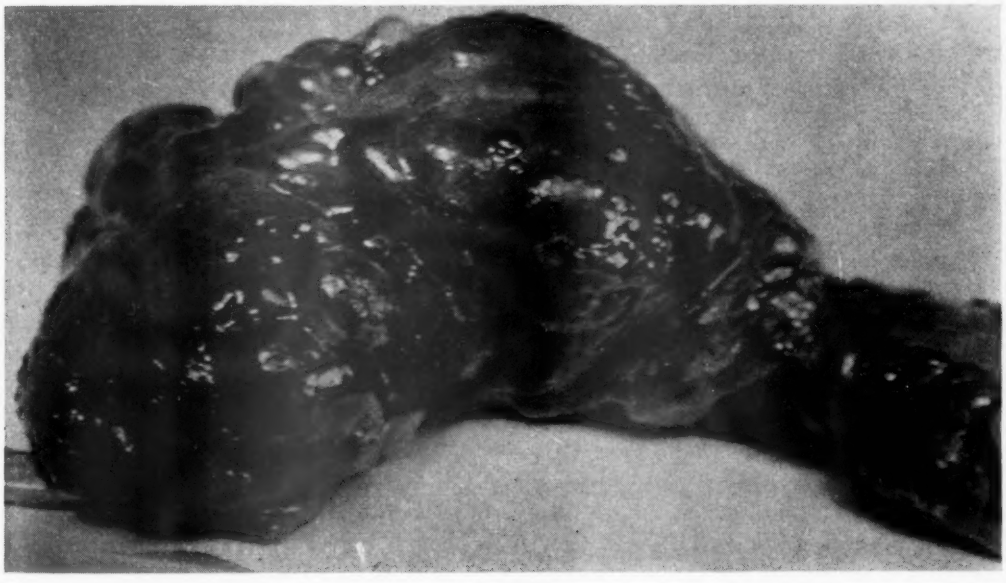

Fig. 3.—Resected segment of jejunum. The involved proximal end is at least twice the diameter of the adjacent normal bowel.

The most significant observation in support of this concept was advanced by Tung and Ngai.[8] During a laparotomy on a patient with pyloric obstruction and pneumatosis of the small intestine, they observed the passage of air into the gas cysts after the patient vomited. The cysts immediately increased

in size without simultaneous distention of the bowel. Stiennon[9] recently suggested that gas under pressure spreads from the site of the obstruction by retroperitoneal extension. The gas may dissect subserosally and present beneath the diaphragm, or it may follow the perforating blood vessels and enter the submucosal space. For this reason, pneumatosis intestinalis should be suspected in any patient with prolonged or recurrent pneumoperitoneum, if the cause is not apparent.[10]

Primary pneumatosis can occur, but the majority of reported cases are associated with obstruction of the gastrointestinal tract and with mucosal ulceration. In adults, stenosing peptic ulcer has been the most common associated disease (over 50 per cent),[11] but carcinoma of the stomach or intestinal obstruction may be the underlying condition. Pneumatosis may be confined to an intestinal loop constricted by adhesions or volvulus, or to one containing intestinal parasites. In infants, diarrheal disease most frequently coexists.[12]

Pathology.—The most common location for abdominal gas cysts is the terminal ileum, with the cecum, ascending colon, and jejunum, in that order, being next in frequency. Less frequent locations are the stomach, duodenum, gall bladder, gastrohepatic ligament, falciform ligament, mesocolon, omentum, and lymph nodes.[7] Emphysema may also occur in the vagina (pneumatosis vaginae) or urinary bladder (pneumatosis vesicae), and probably has the same pathogenesis.[12]

Grossly, the condition looks like soap bubbles or a hydatidiform mole. There are multiple thin-walled cysts situated in the wall of the intestine, mesentery, or extraperitoneal areas, varying in size from 1 mm. to over 5 cm. in diameter. They may occur singly or in clusters. In infants the cysts are chiefly submucosal, while in adults they are predominantly subserosal. The bowel wall containing intramural air cysts is usually thickened, resembling sponge rubber. Localized cysts may produce polypoid mucosal projections.

Microscopically, there is no characteristic histopathologic picture. Usually the cystlike spaces appear empty and are surrounded by a wall of connective tissue or flat endothelial-like cells resembling ruptured lymph spaces. Giant cells have been described, particularly in adults, with small round-cell infiltration and fibrosis consistent with chronic inflammation.

Diagnosis.—There are no diagnostic clinical findings in pneumatosis cystoides intestinalis. Usually the underlying disease, most often incomplete intestinal obstruction, produces the predominant symptomatology.

Rarely, pneumatosis intestinalis may initiate intestinal obstruction. Recognized mechanisms of obstruction are: narrowing of the bowel lumen by submucous cysts (seen in infants), volvulus, compression of the intestine by an extrinsic mass, or constriction by adhesions engendered by the cysts.[7] Submucosal cysts may also be the starting point for an intussusception.[11]

The x-ray picture is typical. It consists of radiolucent shadows outside the bowel lumen, with reticulated lines representing cyst walls.[13] Roentgenograms may show pneumoperitoneum with archlike lines, which does not shift like free air. In some instances the presence of loops of small intestine be-

tween the liver and diaphragm (the Moreau-Chilaiditi syndrome) is very suggestive.[12] Pneumoperitoneum in a patient with peptic ulcer is said to be pathognomonic of pneumatosis if perforation can be excluded.[5, 15]

Treatment.—Surgical treatment should be directed toward correction of the underlying disease. In most cases the cysts disappear spontaneously after treatment of the coexisting diseases. Resection is usually reserved for localized segments exhibiting advanced changes and in which subsequent intestinal obstructions may occur. If the gas becomes walled off and encapsulated by fibrous tissue, resorption is extremely slow.[13]

SUMMARY

1. A typical case of pneumatosis cystoides intestinalis in a Korean man has been presented. This was successfully treated by intestinal resection.

2. The probable mechanism, clinical features, diagnosis, and treatment of pneumatosis intestinalis are discussed.

3. This condition presents characteristic x-ray signs and can be diagnosed preoperatively, if suspected.

4. The persistent formation and rupture of gas cysts comprise the only known condition which can readily explain a prolonged or recurrent pneumoperitoneum.[10]

5. To our knowledge, this report represents the forty-fifth case of pneumatosis intestinalis in the American literature and the fifth to be diagnosed preoperatively.

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TEN-YEAR SURVIVAL FOLLOWING PANCREATODUODENECTOMY FOR CARCINOMA OF THE AMPULLA OF VATER

Case Report

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IN AN authoritative review of the surgical treatment of carcinoma of the ampullary region and head of the pancreas in 1952, Orr[5] listed seventeen patients collected from the literature who had survived pancreatoduodenectomy for five years or more (four cases of carcinoma of head of pancreas, ten cases of carcinoma of ampullary region, three cases not specified). Since this report, five additional cases of five or more years' survival following pancreatoduodenectomy for carcinoma of the ampulla of Vater have been reported in the American literature: one case by Brunschwig,[2] three cases of ten years' or more survival by Bennett,[1] and one case by Siler.[6] Likewise two additional five-year survivals following pancreatoduodenectomy for carcinoma of the pancreas have been reported by Clifton.[3] (One of these two patients died of a probable recurrence five years and four months after operation.)

In view of the relatively limited number of patients reported in the American literature to have survived five or more years after radical surgical treatment of carcinoma of the ampulla of Vater or head of the pancreas, the following patient who has now lived ten years after pancreatoduodenectomy for carcinoma of the ampulla is reported. This patient was originally reported by Cole and Reynolds[4] in 1945.

CASE REPORT

G. S., a 48-year-old Negro woman, entered the University of Illinois Research and Educational Hospital, April 13, 1944, complaining of jaundice and severe itching. The patient first noted the development of painless jaundice and itching approximately three years prior to admission. At that time the patient's stools were clay colored, but the symptoms gradually cleared after three months without treatment. One year prior to admission the patient again noted the development of painless jaundice accompanied by itching. In August, 1943, a cholecystectomy was performed at another hospital. The gall bladder was reported to have been large and distended, and to contain no stones. Following this operation there was drainage of bile from the wound for two months. The jaundice and itching recurred soon after the biliary fistula closed.

On physical examination the patient was noted to be markedly jaundiced. The liver edge was palpable two fingerbreadths below the costal margin. No other abdominal masses were felt. The hemoglobin was 6.5 Gm., red blood cells 2,800,000, and white blood cells 11,700. The urinalysis was negative except for the presence of large quantities of bile. The serum albumin was 3.0 Gm. and serum globulin 2.5 Gm. The icterus index was 53, and the blood amylase was 326 (upper limit of normal 150). The stools were acholic.

Received for publication June 15, 1954.

Following multiple transfusions, celiotomy was performed on May 1, 1944. Numerous adhesions were present in the upper abdomen. A small stump of the gall bladder remained. In the duodenum at the site of the ampulla of Vater was an irregular, indurated mass measuring approximately 3 by 5 cm. This mass appeared to be neoplastic and to be arising from the ampulla of Vater. No metastases were noted. The duodenum and head of the pancreas were resected (Fig. 1). The duodenum was cut across two to three inches from the ligament of Treitz, and the distal end of the duodenum was closed with a double row of catgut sutures. The proximal end of the duodenum was cut across at the pylorus. A loop of jejunum was brought up anterior to the colon for anastomosis with the common duct and stomach. The cut end of the pancreas was closed with interrupted cotton sutures. An end-to-side anastomosis of the end of the stomach and the jejunum was made approximately eighteen inches from the ligament of Treitz. The common duct was then implanted into the jejunum proximal to the gastrojejunal anastomosis. (Thus gastric contents would not flow over the opening of the transplanted common duct.) The remnant of the gall bladder was not disturbed. A Penrose drain was placed near the stump of the pancreas.

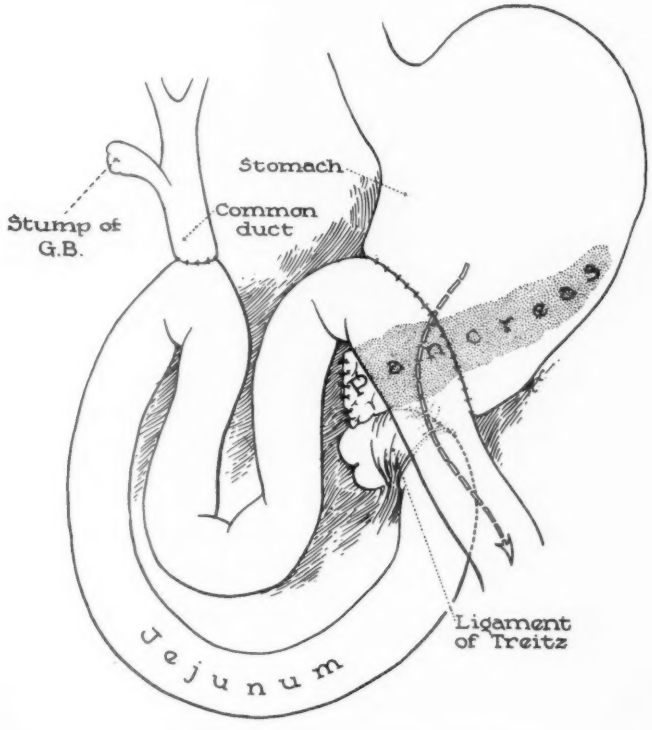

Fig. 1.—Diagram of operative procedure.

Microscopic diagnosis was papillary adeno- and gelatinous carcinoma of the ampulla of Vater involving the duodenal wall and head of the pancreas. Postoperative course was relatively uneventful and the patient was discharged from the hospital on the sixteenth postoperative day.

Drainage from the stump of the pancreas continued for four months. During this period of time the patient's weight gradually increased from the early postoperative level of 82 pounds to 95 pounds. The patient had seven to eight large, bulky, light yellow-brown stools daily despite the administration of large doses of pancreatin.

One year after surgery the patient's serum icterus index was 4. The patient continued to have frequent bulky stools. The patient at this time weighed 104 pounds. In March, 1946,

while she was hospitalized for the performance of a hemorrhoidectomy, the diagnosis of mild diabetes was made and the patient was placed on insulin and dietary management.

In November, 1945, the patient had a severe attack of epigastric pain which required morphine for relief. The patient reported that she was jaundiced for a short period of time following this episode. Physical examination confirmed the presence of jaundice. The liver edge was palpable below the costal margin but was not nodular. No other abdominal masses were palpable.

Celiotomy was performed on Jan. 8, 1947, with a preoperative diagnosis of obstructive jaundice secondary to recurrent carcinoma. At operation several stones were found in the common duct proximal to the anastomosis with the jejunum. The liver was large but no metastatic nodules were noted. There was also a cystic mass the size of a tennis ball slightly to the left of the midline which proved to be a cystic dilatation of the end of the pancreas. Aspiration of this cyst revealed brownish green fluid which was under tension. A longitudinal incision was made at the junction of the common duct and jejunum. A partial diaphragm was found to have formed in the opening between the common duct and the jejunum. Above this partial diaphragm were several large and small stones. After removing the stones it was possible to pass a probe up into the right and left hepatic ducts. The longitudinal incision was enlarged and then closed transversely after excision of the occluding diaphragm. The cystic dilatation of the pancreas was then anastomosed to the jejunal loop. The wound was closed in layers after inserting a Penrose drain down to the site of the anastomosis of the common duct and jejunum. The postoperative course was essentially uneventful and the patient was discharged from the hospital on Jan. 26, 1947.

The patient was found to require greater daily insulin dosage following this last operation (protamine zinc insulin 30-0-0- units and regular 55-0-0 to 20 units). The patient continued to have four to five large bulky stools daily. Since 1947, the patient has been examined at regular intervals in various clinics of the Research and Educational Hospitals. Her lowest weight since 1947 has been 111 pounds and her highest weight 119 pounds. She was last examined on May 24, 1954, and was asymptomatic at that time; there was no evidence of recurrent carcinoma. The patient's weight at that time was 111 pounds. She has relatively normal bowel movements except for occasional loose stools. She takes 7 to 8 five-grain pancreatin tablets three times a day and 20 units of NPH insulin. At the time of the last examination the patient was 58 years old.

SUMMARY

A case of carcinoma of the ampulla of Vater with the patient now living and without evidence of recurrent disease ten years after pancreatoduodenectomy is reported.

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ABNORMALITIES OF THE PANCREATIC DUCT SYSTEM AS A CAUSE OF PANCREATITIS

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NUMEROUS mechanisms of occlusion of the biliary ductal system have been demonstrated as a cause of pancreatitis. The purpose of this communication is to describe a case in which anomalous development of the pancreatic ducts resulted in their obstruction by the overlying common bile duct.

INTRODUCTION

The Opie common channel theory provides an adequate etiological basis for many cases of pancreatitis.[1-5] A variety of mechanisms have been described as causing obstruction of the common outlet of the pancreatic and biliary tracts. These include calculi, tumors, sphincter spasm, ductal metaplasia, and pressure changes resulting from local inflammation.[2, 3, 6-10]

The following case demonstrates that an anomalous embryonic development of the biliary and pancreatic duct systems may result in obstruction of the pancreatic ducts by an overlying common duct. It is felt that this was of etiological significance in producing pancreatitis in this instance.

CASE REPORT

A 32-year-old white man was transferred to the Veterans Administration Hospital in Denver, on July 10, 1952, with a four-year history of anorexia, gaseous eructations, mild fatty food intolerance, and progressive alcoholism.

Six weeks prior to admission he underwent an exploratory laparotomy for severe epigastric pain which was thought to be due to a perforated peptic ulcer. Postoperatively he developed multiple abdominal abscesses and required reoperation when the diagnosis of acute pancreatitis was confirmed. On admission to the Veterans Administration Hospital the patient had four draining abdominal fistulas, exhibited severe electrolyte imbalance, had bilateral pleural effusion, and was in shock.

His early response to supportive therapy was encouraging, but his course was that of progressive deterioration and he expired seven weeks after admission. Autopsy revealed bronchopneumonia, toxic nephrosis, pancreatitis, and generalized peritonitis.

The pancreas was surrounded by a large hemorrhagic abscess. The common bile duct had a separate opening into the duodenum 8 cm. distal to the pylorus. The pancreatic ducts emptied into the duodenum 2 cm. beyond this. The duct of Santorini was compressed by the common bile duct, which overlay it for a distance of 2 cm. proximal to its junction with the duct of Wirsung, the latter being occluded by two firm calcific stones 0.5 cm. from the pancreatic papilla. Thus, occlusion of the entire pancreatic ductal system had occurred. (Fig. 1, *F*.)

DISCUSSION

This abnormal relationship between the pancreatic duct and the common bile duct represents an unusual embryologic pattern. Normally the pancreas

Received for publication June 22, 1954.

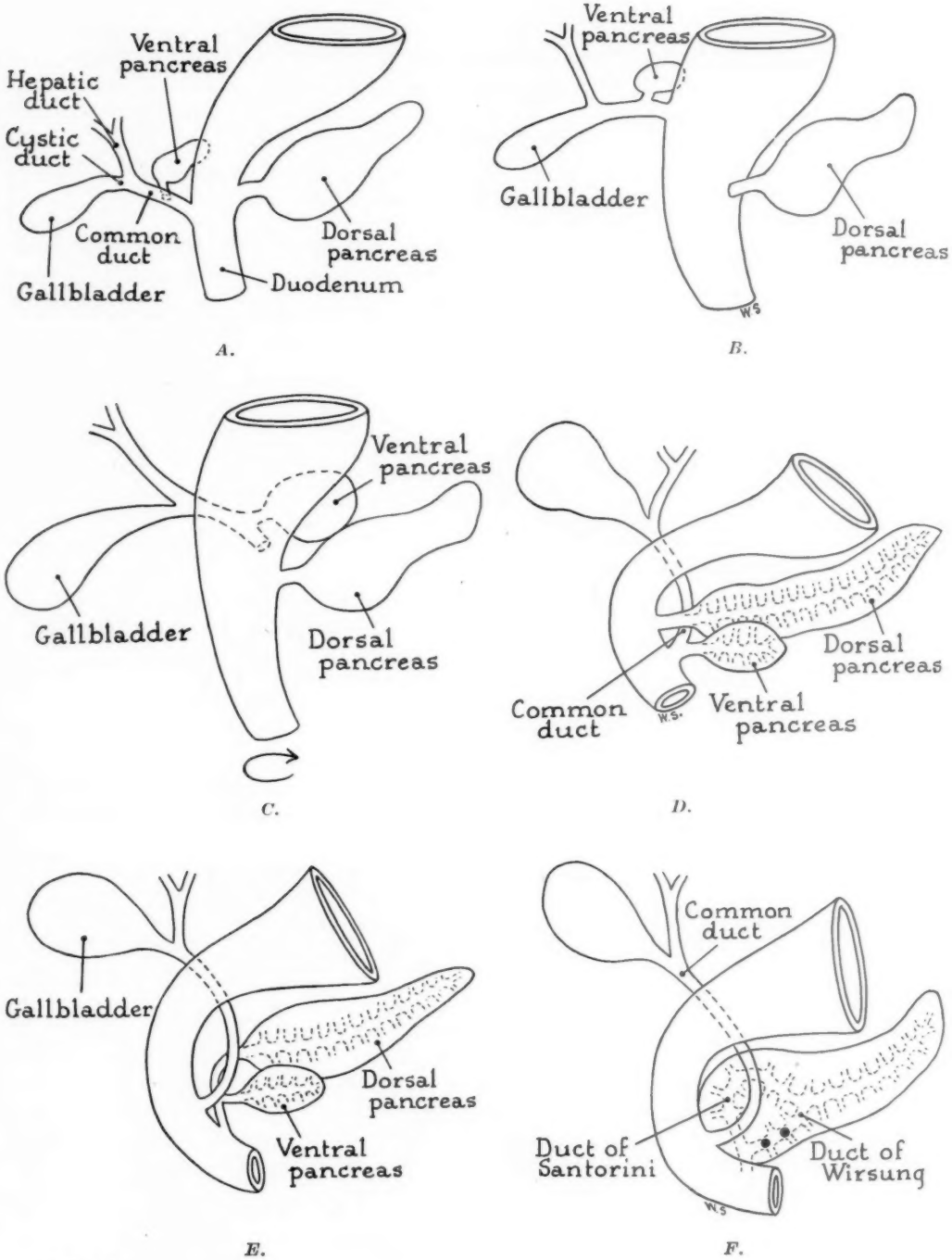

Fig. 1.—

A, Early embryologic development of pancreas (after Arey[12]).

B, Early embryologic development of case described. Note high tube off of common bile duct.

C, Rotation of ventral pancreas in case described.

D, Normal pancreatic and biliary duct relationship (after Arey[12]). Note pancreatic duct anterior to common duct.

E, Relation of pancreatic and biliary ducts in case described with common duct anterior.

F, Pathologic finding in case described with occlusion of duct of Santorini by overlying common duct and occlusion of duct of Wirsung by calculi.

is formed by the fusion of two outpouchings from the intestinal tract. The major portion of the pancreas is formed by a dorsal entodermal bud which arises from the duodenum and contains the duct of Santorini. The head of the pancreas containing the duct of Wirsung is formed from a slightly more caudad anterior outpocketing from the common bile duct which swings to the left and fuses with the dorsal anlage as the latter is pulled to the left by the rotation of the intestine. The two ducts also fuse at this time, with the duct of Wirsung normally providing the main avenue of pancreatic drainage.[11-13] (Fig. 1, *A* and *D*.)

The duct of Santorini then normally lies anterior to the common duct, but in this case relationship was reversed. This situation might have been produced by an abnormally high-lying bile duct anlage with exaggerated rotation of the duodenum, thus looping the common bile duct, with its attached ventral pancreatic bud, over the dorsal pancreatic duct lying to the left of the intestine. The common bile duct then would lie anterior to the pancreatic duct of Santorini as this dorsal bud enlarged. As fusion of the ductal system occurred, the orifice of the duct of Santorini lay distal to the common bile duct, constituted the main pancreatic drainage pattern, and was apparently joined by the duct of Wirsung distally. (Fig. 1, *B, C, E,* and *F*.)

The occlusion of one duct by such a developmental abnormality ordinarily would be of no clinical significance, but in the case here described the alternate path of drainage (the duct of Wirsung) was occluded by calculi, resulting in complete pancreatic obstruction.

Numerous developmental abnormalities of the pancreas have been shown to be of significance in the etiology of pancreatitis, but the anatomic abnormality as presented in this case has not previously been described.[14-18]

CONCLUSION

A case of pancreatitis has been described in which obstruction of the pancreatic duct system resulted from an anomalous location of the common duct which overlay the pancreatic duct and caused its occlusion. This case represents a mechanism of pancreatic duct obstruction not previously reported and suggests that extrinsic pressure on the pancreatic duct by the common bile duct may be of etiological importance in occasional cases of pancreatitis.

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ARTERIOVENOUS FISTULA OF THE RENAL VESSELS

A Case Report

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DESPITE the close proximity of the renal arteries and veins, the development of a fistula between them is rare. Hamilton, Getz, and Jerome[1] found only three proved cases in the world literature prior to 1953, and added a fourth. We have found that an additional case was recorded by Adams,[2] and the one we are reporting is the sixth, as far as we can determine. Four of the previously recorded cases were considered to be congenital in origin and the fifth apparently resulted from infiltrating adenocarcinoma of the kidney. The etiology in our case is not entirely clear, even after careful study of the lesion. It apparently could have been either traumatic or congenital in origin.

CASE REPORT

This 22-year-old white premedical student was transferred to the Philadelphia Veterans Administration Hospital on Dec. 18, 1954, from the Wilkes-Barre Veterans Administration Hospital, where a loud bruit was heard in the left upper quadrant of the abdomen. He had noted easy fatigability and dyspnea on exertion for several months. These symptoms were not severe enough to interfere significantly with his activities. There had been no swelling of the ankles, cough, or hemoptysis. He had been in good health all his life and had had no serious illnesses or operations. Two traumatic events seemed of possible significance. In September, 1951, he fell twenty feet down the hatch of a Naval vessel, sustaining a moderately hard blow on the back. He rested for several days because of back pain, which was not localized to either the right or left side. He did not think he was seriously injured at the time. In July, 1952, he sustained a gunshot wound of the chest. A 32-caliber bullet entered the right anterior axillary line about one inch above the nipple level. He was hospitalized for several days. Later he was told that x-ray films showed the bullet to be in the upper abdomen and that small amounts of blood were found in the urine.

On physical examination the patient appeared to be robust and healthy. The average of several blood pressure recordings was 160/60. There was evidence of moderate enlargement of the heart. A systolic murmur was heard at the apex. There were no signs of cardiac failure. The most striking physical sign was a loud continuous machinery-like murmur in the left upper quadrant of the abdomen. It was similar to the murmur of a patent ductus arteriosus. The intensity was approximately the same anteriorly, laterally, and posteriorly. The murmur could not be heard more than one or two inches to the right of the midline. When the patient was lying in the prone position, a thrill was palpable in

Received for publication June 24, 1954.

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the left upper quadrant. The pulses in the lower extremities were strong and full. The blood pressure in the legs was approximately the same as in the arms. There were no other significant physical findings.

Routine blood counts and urinalyses were within normal limits. The blood urea nitrogen was 16 mg. per cent. The venous pressure in an antecubital vein was 130 mm. of water. An increase in the amplitude of QRS complexes was seen in the precordial leads of the electrocardiogram, but this examination was not otherwise remarkable.

The chest x-ray film was essentially normal except that the heart was estimated to be about 30 per cent larger than normal. A 32-caliber bullet, which was seen about one inch below the dome of the right diaphragm in the anteroposterior view, was about midway between the front and back on the lateral view. It was, therefore, almost certainly lodged near the dome of the liver. An intravenous urogram demonstrated good function of both kidneys with normal pelvocalyceal systems but some lateral deviation of the upper portion of the left ureter. There were no changes in the spine or transverse processes indicative of a previous fracture.

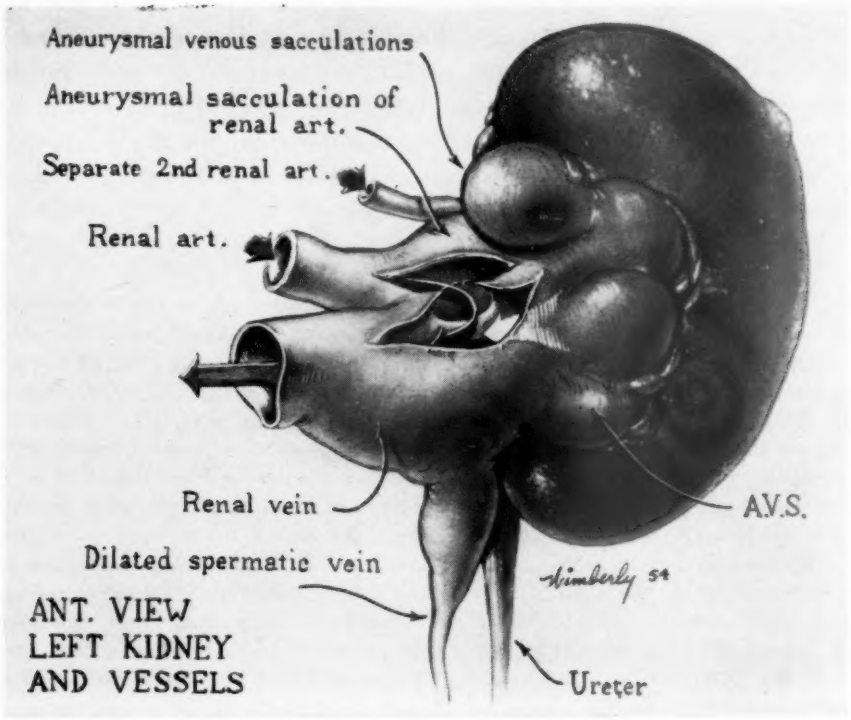

Fig. 1.—Artist's concept of the resected specimen. The site of the fistula and the two renal arteries are shown. The sacculations of the renal vein appeared somewhat larger when the lesion was exposed at operation.

It seemed certain that this patient had an arteriovenous fistula in the left upper quadrant of the abdomen, as evidenced by the characteristic murmur, the widened pulse pressure, and the cardiac enlargement. It was hoped that further information about its location might be obtained by aortography. The usual translumbar technique was used. Twenty-five cubic centimeters of 70 per cent Urokon sodium was injected into the aorta just below the diaphragm, and films were exposed at 0.50-second intervals for fifteen seconds, with the Fairchild Serialographic Camera. The essential findings of the x-ray report (by G. T. W.) were as follows: Excellent delineation of the aorta was obtained. A large vascular mass was demonstrated extending to the left of the aorta at the level of the left renal artery. The right renal artery was also demonstrated and this confirmed our

belief that we were dealing with a large left arterial venous fistula with the resulting large volume flow of blood through this fistula. It was believed that this represented the venous components of the renal veins, with the spermatic vein and the arcade of venous structures within the kidneys. The aorta beyond the level of the renal artery was not demonstrated, apparently because of the large volume flow of blood through the fistula and diminished volume flow into the distal aorta.

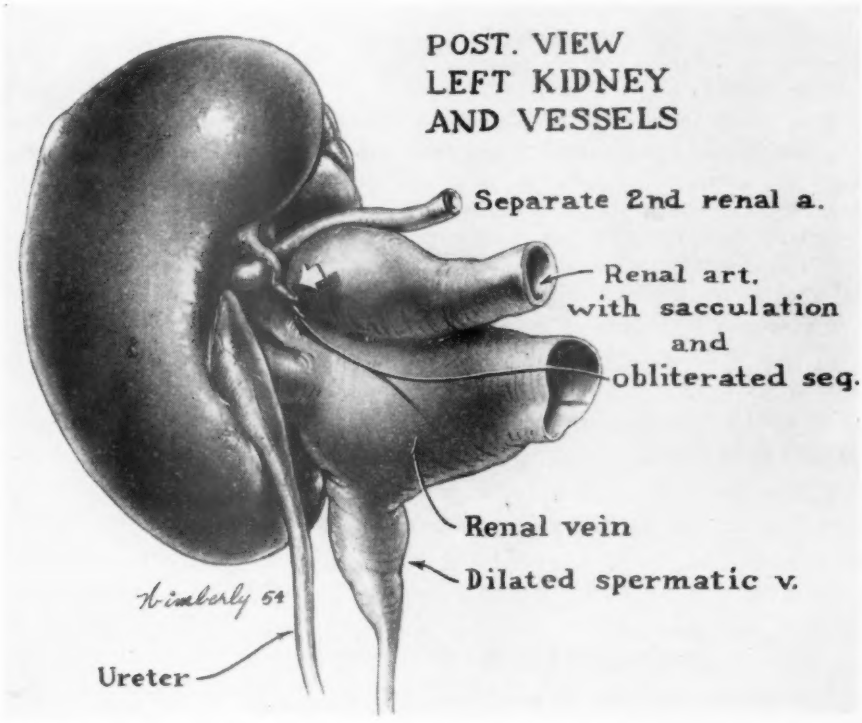

Fig. 2.—Posterior view of the resected specimen. The relationship of the two renal arteries and the constricted area distal to the fistula is accurately shown.

Operation was performed on Jan. 7, 1954. A left thoracoabdominal incision was made, beginning in the seventh intercostal space with the patient in the right lateral position. The left diaphragm was incised radially, halfway to the esophageal hiatus. Hernia tapes were passed around the aorta just above the level of the diaphragm and below the inferior mesenteric artery so that hemorrhage due to a technical accident could be minimized. The large aneurysmal sac was then exposed. It extended over most of the anterior surface of the kidney and up over the spleen anteriorly. There were a number of rather large outpouchings, the limits of which were well demarcated by the strong thrill. The wall of the sac was thinner than that of a normal vein in many places but, fortunately, was not perforated at any time and there was no significant bleeding during the dissection. None of the veins of the portal system seemed to be involved. It appeared that the safest procedure was to approach the arterial end of the fistula by exposing the aorta from above and below. Cautious dissection posteriorly finally led to exposure of the base of the left renal artery, occlusion of which obliterated the thrill. Nephrectomy was obviously necessary. The renal artery was first ligated and divided. This reduced the pressure in the huge venous sac and permitted safe dissection of the rest of the vascular pedicle, which was then secured with suture ligatures and divided. Finally, the ureter was ligated and divided and the specimen was removed. The patient was in good condition throughout the proce-

dure. There were mild alterations of blood pressure, and immediately following removal of the kidney the pressure dropped to 100/70. It came up quickly again, however, and obliteration of the fistula did not appear to cause any significant immediate effect.

The postoperative course was smooth and uncomplicated. The blood pressure remained between 150 and 180 for several days, and then gradually declined to about 120 to 130 mm. of mercury. This was regarded as the characteristic response due to increased blood volume with a gradual decline as the blood volume contracted. A chest x-ray film on the thirteenth postoperative day revealed that the heart had returned to approximately normal size. The patient was discharged on the eighteenth postoperative day. He was examined three months after operation and has remained in good health.

The essential features of the resected specimen are depicted in artist's drawings (Figs. 1 and 2). There was a dual arterial supply, one artery being essentially normal and the other giving rise to the fistula. The latter artery was somewhat enlarged, measuring 2.5 cm. in diameter at the point of origin from the aorta. The fistula, which was about 3.5 cm. from the aorta, was 0.8 cm. in diameter. Just distal to the fistula the artery was constricted, with the lumen pin-point in size for about 1 cm., and then the lumen appeared to be normal in diameter. On microscopic examination, there was extensive subintimal and medial fibrous proliferation in the area where the artery was greatly narrowed, distal to the fistula. There was subintimal fibrous proliferation of the wall of the sac. The kidney and adrenal gland appeared normal.

COMMENT

Our first impression, upon seeing this patient with an arteriovenous fistula in the upper abdomen and a bullet not far from the region of the murmur, was that the bullet must have caused the lesion. The discovery of the exact location of the fistula at operation cast some doubt upon this theory, however. Since the bullet entered the right anterior axillary line just above the nipple level and is now lodged near the dome of the liver, an important assumption is necessary if the bullet is to be implicated. This is that the bullet struck the spine and ricocheted. The odds against the bullet behaving in this manner would seem to be high and yet it is well known that bullets not uncommonly take an even more bizarre and unexpected course. If the bullet had lodged in the left lower quadrant of the abdomen, it seems unlikely that anyone would have doubted that it caused the fistula.

The blow on the back in September, 1951, when the patient fell down backward for a distance of twenty feet, might also have caused the fistula. The chief argument against this hypothesis is statistical, in our opinion. A great many young men have undoubtedly sustained similar injuries and yet there are no recorded instances of a fistula of the renal vessels following such an injury, unless it might be the case reported by Rieder.[3] Experience has shown that traumatic arteriovenous fistulas are almost invariably caused by penetrating metallic objects, rather than by blunt force.

The possibility that the fistula was congenital in origin cannot be excluded. In four of the five previously recorded cases, it was thought that a congenital aneurysm of the renal artery probably eroded into a renal vein. The gross and histologic findings in our patient are compatible with this sequence of events.

Two features might be regarded as slightly more in favor of a traumatic than a congenital origin. One is that the communication between the artery

and vein was quite large and the symptoms were of relatively short duration. The other is that the thickening and narrowing of the arterial segment just distal to the fistula had an appearance that might be regarded as more characteristic of posttraumatic fibrosis. It is our opinion, though, that both the gross and microscopic examinations were compatible with either a traumatic or congenital etiology.

The relatively normal preoperative intravenous urogram was apparently made possible by the presence of a dual arterial supply to the kidney. This is not an uncommon anatomic finding, according to Anson and Cauldwell.[4] The anatomic features of the specimen removed at operation have been well delineated by special radiographic studies performed by one of us (A. P. G.). These are described and illustrated in a separate communication.[5]

SUMMARY

We have described what we believe is the sixth proved case of an arteriovenous fistula of the renal vessels. The lesion was cured by a nephrectomy. Even after careful study of the resected specimen it is not entirely certain whether this fistula was of congenital or traumatic origin.

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Editorial

The Iron Curtain

MANY years ago the world was a peaceful place. There were wars, but they were conducted in a gentlemanly manner by professional soldiers, and when the war was over, the victorious nation apologized to the vanquished, sent them supplies to replace those they had lost, and lent them money to re-establish their trade. Between wars the citizens of every nation visited each other, to travel, to trade, often to take up permanent residence. But there rose a wicked ogre with an enormous moustache who was the ruler of a great and powerful state. When the neighbouring states went to war, he armed his men and drilled them and built tanks and airplanes, and waited to see which side was likely to win. Then he threw in his force on that side, but not too much. He insisted that his allies should fight the sea battles and the air battles, should send him supplies and weapons that they could ill spare, and should communicate to him all their secret inventions. When the war was won he took all the wealth of the vanquished back to his own land, and carried their wise men away with him as prisoners. He closed all his frontiers so that the people of other lands could no longer trade with his country or even visit it, and his people could no longer visit their neighbours.

Even so it was with surgery. Many years ago the domain of surgery was a fair land where all could wander at will. Some surgeons spent their lives in visiting every part of the territory. Some, after wandering, settled down to cultivate one part, but they were always ready to welcome those who chose to work beside them. Some, after settling in one place, transferred their allegiance to another. A common interest linked them all, and passports were unknown. But there arose a group of surgeons who found a province that had hitherto been worked very little, one that because of new inventions could now be cultivated profitably and offered a rich harvest. This they proceeded to claim as their own, and they closed its frontiers to all except those in possession of a password which they communicated only to a few. What made their policy easier was that this province was marked off by anatomic boundaries more exact than those delineating any other, by the ribs all round, by the diaphragm below, and above by an aperture too narrow to encourage access. Intruders ventured from time to time to enter from above in brief raids after a wandering goitre, but they worked from outside the forbidden frontiers, and they made only a brief incursion to detach their trophy. The territory of the thoracic surgeons would be as closed today as that of the Commissars, were it not for the oesophagus which is part of an alimentary canal that is mainly abdominal. The opening which permits the oesophagus to pass through the diaphragm is the hole in the iron curtain.

The oesophageal hiatus is an oval opening in the right crus of the diaphragm where the fibres run vertically rather than horizontally. The opening thus lies obliquely round the oesophagus, exposing an inch of "abdominal oesophagus" in front, but fitting snugly round the gastro-oesophageal junction behind. In this opening the oesophagus lies loosely, and once the overlying peritoneum has been divided it can easily be pulled down. Some muscle fibres may pass from the diaphragm to the oesophageal wall, but the attachment of the oesophagus at the level of the hiatus depends rather on fibrous bands and on the branches of the left gastric artery than on any muscular slips.

Herniation through the oesophageal hiatus in the diaphragm was known to Astley Cooper 150 years ago, but only within the last twenty years has it been recognized as a relatively common complaint. Avery Jones reports that five cases were found by the radiologic department of the Central Middlesex Hospital in 1947, ten in 1948, fourteen in 1949, thirty-eight in 1950, and sixty-one in 1951. The number of radiographic examinations was roughly the same in the last three years, and the increasing number of hiatus hernias discovered is an indication of increasing awareness of the lesion on the part of clinicians and increasing skill in demonstrating it on the part of radiologists.

Is it congenital or acquired? The structure of the hernia shows no evidence of anatomic defect or developmental failure; the sac, which may be absent, is merely a protrusion of the abdominal peritoneum, the opening is surrounded by the stretched but intact fibres of the right crus. The condition is found in babies, but babies suffer from and do many things that tend to increase the intra-abdominal pressure and to protrude the contents of the abdomen through any weak spot in its walls. The majority are found in middle-aged obese women who have some other disability that has led to the investigation that discovered the hernia.

To a surgeon the surprising thing is, not that there are so many hiatus hernias, but that they are not universal, for the hiatus is no secure barrier. When searching the abdominal cavity at laparotomy for a suspected carcinoma it is usually found that some two inches of the thoracic oesophagus can easily be pulled into the abdomen for palpation, and that three fingers can be introduced without trauma into the hiatus. It is not merely possible, but probable, that whenever we cough, and whenever we stoop to do up our shoelaces, we push a little bit of oesophagus through the hiatus and sometimes a little bit of stomach with it. By the time we are middle-aged, when coughing has become a regular morning affliction, when the daily visit to the lavatory demands prolonged straining, and when our shoes are reached only with much grunting and difficulty, the temporary displacement has become a habitual herniation. It is certain that when we suspect a hiatus hernia in an adult and are unable to demonstrate it by the ordinary means, if we ask the radiologist to take a lateral film of the patient in a stooping position we can very often find one. Well-developed and easily demonstrated hernias are found in something like 10 to 15 per cent of people above middle age.

The importance of hiatus hernias lies, not in the herniation of the stomach into the thorax, but in the incompetence of the cardiac mechanism that accompanies it. The need for surgery arises when simple medical and dietetic measures fail to give relief after conscientious trial, or when complications develop, chiefly peptic ulcer of the oesophagus and its sequelae, major haemorrhage and stenosis.

The oesophageal hiatus may be approached through the abdomen or through the chest. I have in my library nine books, American and British, dealing with operative surgery, and I have consulted others in the library of the Royal College of Surgeons. All of them illustrate the approach from below. In my view this method is a heritage from the days before controlled respiration anaesthesia and the discovery of the antibiotics, and I would always approach this region through a long incision on the left side of the chest after resecting the eighth rib. The gastro-oesophageal junction is near the summit of the diaphragmatic dome; the approach to it from the thorax is a direct one across an empty space, the approach from the abdomen is an exploration into a deep hole overhung by the costal margin, filled with gaseous viscera that must be kept out of the way by towels and retractors, and obstructed by the left lobe of the liver that must be mobilized before it can be retracted. A good technician with good light and good assistance can overcome the anatomic difficulties of the abdominal approach, but there is the further disadvantage that the oesophagus, whether ulcerated in hiatus hernia or inflamed in achalasia, is often adherent to the tissues in the posterior mediastinum and cannot be mobilized without dissection.

I myself, a general surgeon, use the thoracic approach for the repair of hiatus hernias and have every reason to be satisfied with it. Such of my thoracic colleagues as I have watched at work perform the same operation from below. What is the answer? The answer, surely, is that each of us believes that he is right and is prepared to argue the point, but that out of the debating chamber we remain friends. We each know the limits in which our work is set, but we each claim the right for ourselves and our colleagues to step over those limits if we consider it necessary. Above all we believe with the fervour of a religion, that if ever the day comes when a surgeon is circumscribed by rigid frontiers which he may not transgress without penalty, the end of surgery as a progressive science will be in sight.

But it is time to drop the simile of the iron curtain. The name has grown up to describe the rigid political frontiers with which one country has chosen to surround itself, frontiers whose only purpose is to prevent those within from escaping and those without from bringing the light and laughter of happier lands to the prisoners within them. In the surgical sense the diaphragm is a political barrier, but a one-way affair, a boundary to keep competitors out of the thorax while allowing those who claim it as their province to raid the territory of their neighbours. Here, however, the comparison must end. The political boundary is fixed and rigid, the diaphragm is mobile and soft. The political curtain benefits no one; the diaphragm is

an essential part of the abdominal as well as of the thoracic mechanism. The political curtain prohibits that circulation which is the world's life. The diaphragm is not merely the chief muscle of respiration, but also an essential part of the mechanism of circulation. Each time it descends, it increases the positive pressure below it and the negative pressure above it, emptying blood from the vena cava into the right auricle. Each time it ascends, it fills the veins below it from the limbs and empties those above it into the heart. Further, by giving anchorage to the pericardium it holds the great vessels, and through them the atrioventricular ring, about which the four chambers of the heart are grouped and through which the four valves function, suspended in mid-thorax by elastic guys.

I would plead that the diaphragm should be treated by surgeons with greater respect than it is at the present time, and particularly that it should not be sacrificed unnecessarily. The abdominothoracic incision, in many instances in which it is used, is needless phrenoclasis.

A surgical incision should satisfy three requirements at any rate: It should give adequate access to the site of operation, it should avoid damage to important structures, and it should, after healing, leave the parts it has traversed as strong as they were before. The abdominothoracic incision gives access so adequate that it might almost be termed indecent exposure, but it does so at a price that may be considered excessive. First, it cuts right through the rim of the thoracic cage, and this chondrocostal ring is almost as important in the upper framework of the abdominal wall as the pelvic ring is in the lower. A glorified abdominoperineal incision in which the pelvis is sawn across and broken open would give an exposure of the pelvic viscera that would delight the heart of the gynaecologist and proctologist, but it would be considered too traumatic. Is the abdominothoracic incision any less so? The lower margin of the thoracic cage provides the origin to the diaphragm above and the abdominal wall below, and when the two are contracted in violent effort, forms the hoop of the barrel to which the muscles of the shoulder girdle are attached. Once divided, the ring never unites firmly again. Bone can unite by bone, but cartilage never unites by cartilage or even by good fibrous tissue, and the line of cleavage of the thoracic margin remains ever afterward a weak point.

When the diaphragm is split radially it continues to work reasonably well. It still supports the pericardium, still aerates the other lung, still compresses the abdominal veins to some extent. When, however, its attachments are divided and it is split radically from origin to insertion, it ceases to function. The lungs are filled by the flexores digitorum of the anaesthetist or the thrust of a mechanical pump. The air is pushed in by positive pressure rather than sucked in by negative pressure. We do not know exactly what happens at the thin film that separates the coursing red corpuscles from the air in the alveoli, but differential pressure between the gases on each side of the membrane must be an important factor.

The heart too continues to work remarkably well under conditions that are grossly abnormal. Under normal conditions it is slung, through the medium of the pericardium and the great vessels, between the upper thoracic inlet and the central tendon of the diaphragm, between two rhythmically expanding and contracting pneumatic cushions that assist the flow from the veins to the auricles. It continues to do its work with surprising efficiency, but it is doing so under conditions very much like those of a golfer trying to drive while he stands in rubber-soled shoes on a sheet of ice. The lack of positive pressure, and of rhythmic compression, must also hamper the return of venous blood from the lower limbs and the abdomen.

That a patient can keep reasonably well during the course of a two-hour operation with the thoracic cage split open and the thoracic and abdominal cavities thrown into one, is no argument in favour of the approach. It is a compliment to the wonderful power of Nature to cope with adverse circumstances rather than to the surgeon who thinks he knows better than Nature. We should enquire not merely is it possible, but is it necessary? The two most striking features of the surgical scene in the last two years are the fresh ventures that have been made possible by advances in anaesthesia, and the great increase in postoperative morbidity. Is it possible that the two are related; that the passive inflation of the lungs, the abolition for long periods of all muscle tone, the dropping of the arterial pressure, and the dilution of the circulating fluid with every kind of drug and crystalloid may be in part responsible for the atelectasis, the bronchial infections, the pulmonary infarcts, and the thromboembolic complications that are so marked a feature of the postoperative period today?

The abdominothoracic incision is often necessary in military surgery. When a projectile has passed from chest to abdomen, the needs of wound excision and of access to the tear in the diaphragm and to injured structures on each side of it often demand that the thoracic and abdominal cavities shall be thrown into one. The incision is often necessary in access to the liver, and particularly to its dome and to the hilum for the purpose of portacaval anastomosis. The liver is not a displaceable structure, and if the mountain will not come to Mohammed, Mohammed must go to the mountain.

All other abdominothoracic operations are partly abdominal and partly thoracic. Parts of them are better performed from below, parts from above, but no parts are better performed from the side. The operations are very much like any repair job on a mechanism that passes from the surface into a case, or from one compartment to another, an overhaul of the plumbing in a ship, of the control rods in an automobile, of the wires in a radio. These structures are approached above and between decks, inside and underneath the automobile, on the panel and inside the box of the radio, but never by cutting open the side of the ship, the frame of the motor car, or the case of the radio. The main operations, apart from those of necessity, in which the abdominothoracic incision is commonly used today are those for total or proximal gastrectomy, and for resection of oesophageal cancer. It is claimed that these

operations can be performed in less time, with less shock, with a better post-operative course, and with a better final functional result by a double consecutive approach than by the single one.

I personally have no use under any circumstances for partial proximal gastrectomy. In ulcer it removes the useful and harmless half of the stomach and keeps the dangerous half, where ulcers grow, where cancers start, and where the pyloric hormone does its insidious work. In cancer, whether of the lower oesophagus or the cardiac end of the stomach, it fails to remove adequately the main source of lymphatic spread. After all, cancer surgery is the surgery of vascular territories, and the key vessels of the stomach and lower oesophagus are the left gastrics. To me total gastrectomy means removal of the whole stomach, including an inch of duodenum and an inch and a half of oesophagus, with the great omentum, the spleen, and usually the tail of the pancreas up to the junction of the inferior mesenteric and splenic veins. I would perform this operation through a double approach.

Total Gastrectomy.—The patient is in a supine position. The abdomen is opened through a midline approach from xiphisternum to umbilicus. After confirmation that gastrectomy is, in fact, justifiable, the great omentum is detached from the transverse colon throughout its length. At the right-hand end, the dissection is carried across to the duodenum, dividing the right gastro-epiploic artery at its origin from the gastroduodenal artery, and sweeping the lymph nodes accompanying that artery off the head of the pancreas. The right gastric veins are ligated and the duodenum is divided and buried. At the left-hand end the transverse colon is followed to the splenic flexure, so that the whole omentum and its vessels remain with the stomach and spleen, and the peritoneal reflexion from spleen to kidney can be divided.

The mass is then turned up, the left gastric artery is ligatured at its origin from the coeliac axis, and the lesser omentum is followed up to the diaphragm, the lymphatic nodes being swept inward with the stomach, leaving the right crus bare. The stomach is pulled downward, the left lobe of the liver is retracted, and the peritoneum is divided where it sweeps from diaphragm on to oesophagus, as in vagotomy.

The proximal jejunum is now picked up and a Roux-Y loop is constructed, taking care that the free limb is long and well nourished. This loop is closed temporarily with a thread ligature, brought through an avascular area in the transverse mesocolon, and fixed with one stitch to any point on the back of the stomach.

The abdominal incision is closed, and an anchor dressing is fixed on it. The patient, who should have lost no blood as yet and still be fighting fit, is handed over to the anaesthetist, who turns him into the right lateral position while the surgeon changes his gown and gloves.

The thorax is opened by an incision in the bed of the eighth rib, after resecting or, preferably, displacing it. The lung is packed aside, the pulmonary ligament is divided, and the oesophagus is picked up in the posterior mediastinum and followed down to the hiatus. The diaphragm is split

radially from the hiatus for about three inches, and after a few knife strokes to divide the fibrofatty tissue surrounding the cardia in the hiatus itself, the abdominal mass can be pulled through and the operation is practically over. The pancreas is crushed and tied, the jejunal loop is detached from the stomach, the oesophagus is divided, and the specimen goes off to the pathologist. The jejunum is joined to the oesophagus end to end by a double row of sutures, and the chest wall is closed. The thoracic part of the operation should not take more than twenty minutes.

Resection of the Oesophagus.—The operation described is adequate for an oesophageal cancer whose upper end does not extend higher than an inch and a half below the aortic arch. For cancer anywhere near the arch, or higher in the thorax, the oesophagus should be approached from the right pleural cavity. To isolate a malignant growth by blunt dissection from the wrong side of the arch is unsurgical, and to mobilize the arch by ligating the intercostal vessels in order to make this approach possible is like using a hydraulic press to crack monkey nuts. In the right pleural approach, as soon as the vena azygos has been divided between ligatures, the mediastinum opens like a book with the oesophagus standing out like a fish on a plate. It can be freed with ease, and the perioesophagus can be dissected off the aortic wall under direct vision.

The operation, as that for total gastrectomy, is performed in two stages. In the first the patient is supine and the abdomen is opened by a midline incision. The great omentum is divided between ligatures distal to the gastroepiploic arch, and the division is extended on the right to within two inches of the pylorus. On the left it is continued to the splenic flexure, and then the short splenic arteries are divided close to the stomach until the diaphragm is reached on the left of the oesophagus. The spleen and pancreas are not disturbed. The stomach is then turned up and the left gastric artery is ligatured at its origin, and the lesser omentum is divided until the diaphragm is reached to the right of the oesophagus. The left lobe of the liver is now displaced and the stomach drawn down while the peritoneum in front of the hiatus is divided. The thoracic oesophagus can now be pulled down for a couple of inches, as it is in vagotomy, but the object now is not to isolate the vagi, but to isolate oesophagus and vagi together in the areolar space in which they lie. This is easily done by a finger or a small swab on a holder passed through the hiatus and swept round the oesophagus while it is pulled down by the other hand.

The abdomen is closed, and the patient is turned into the left lateral position. The surgeon, on his return, opens the right pleural cavity by an incision at the appropriate level, usually in the bed of the fifth rib. The growth is identified, cancerous nodes are searched for and eventually the oesophagus is mobilized above and below the growth, and the involved region is dissected free with the greatest amount of surrounding tissues that anatomic limits will allow. The boats have not been burned, for the blood supply of the stomach has not been jeopardized, and if the operation proves impracticable even now, no harm has been done.

If resection is decided upon, the incision in the mediastinal peritoneum is continued downward until the posterior mediastinum, already prepared from below, is opened. The mobilized stomach can then be pulled into the chest through the uncut hiatus. It will be found that the fundus can, without undue tension or interference with its blood supply, be taken as high as the cricoid. The oesophagus is divided at the cardiac end, and well above the growth, and the diseased segment is removed. The divided cardia is closed, and the fundus is fixed by interrupted sutures to the endothoracic fascia well above the lower limit of oesophageal division. A circular hole, smaller than the lumen of the oesophagus, is excised from the anterior wall of the fundus, and the cut end of the oesophagus is implanted with two rows of sutures. The thoracotomy incision is closed.

* * *

We Americans and Britons would like to scrap the iron curtain, to beat it into reaping hooks and ploughshares. We cherish no animosity against those on the other side of it. We should like to talk to them (without police in attendance and a microphone under the table). We should like to play with them. We general surgeons would like to scrap the diaphragm as a political boundary. We have nothing against the thoracic surgeons except that some of them are a little too conscious of Divine guidance. If they have secrets, we should like to share them, and we, in turn, might give them a few hints. But we do not want to scrap the diaphragm as an anatomic and physiologic masterpiece.

—*Sir Heneage Ogilvie*

Recent Advances in Surgery

CONDUCTED BY ALFRED BLALOCK, M.D.

FLASH BURN STUDIES ON HUMAN VOLUNTEERS*

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INTRODUCTION

DIRECT exposure of human skin to the heat emitted by an atomic fireball produces a type of thermal trauma usually characterized as a "flash burn." Clinically, such burns are rarely encountered except in military and industrial accidents, where even then the conditions are not comparable.[1] Laboratory studies using various experimental burning techniques and several different animal species have given valuable information about the characteristics of the flash burn, but animal skin may be so different from human skin as not to allow complete analogy to human responses under similar circumstances. In this present study, therefore, flash burns were produced under varying physical conditions on human volunteers, in the belief that such studies would better prepare us to predict and evaluate the problem of mass casualties in the event of atomic warfare.

This study has been directed toward the solution of the following broad questions:

I. What is the incident thermal dose (calories per unit area) required to produce first, second, and third degree flash burns on unprotected human skin?

II. What is the difference, if any, between burns produced by heat delivered at a thermal intensity (calories per unit area per unit time) which is constant with time (square wave) and burns produced when this heat is delivered with an intensity that varies rapidly with time (thermal pulse)?

III. What is the influence of the speed of delivery of heat on the severity of the burn lesion for a given thermal dose?

IV. What is the influence of the spectral quality on thermal injury?

V. What is the influence of the prevailing skin temperature on thermal injury?

SELECTION OF VOLUNTEERS

Volunteers for this study were obtained from the junior medical class and included forty-one male and three female students, all belonging to the white

The technical assistance of Mrs. Evelyn Mueller, Mr. Harry Mueller, and Mr. Raymond Ruffin is gratefully acknowledged.

Received for publication March 11, 1954.

*This study was conducted under Contract number DA 49-007-MD-99 between the Office of the Surgeon General, Department of the Army, Washington, D. C., and the Medical College of Virginia, Richmond, Virginia.

†Dr. Evans died Jan. 14, 1954, before this paper had been submitted for publication.

race. Nine (20 per cent) had light blond hair, twenty-seven (61 per cent) brown hair, six (14 per cent) black hair, and two (5 per cent) were red-haired. Skin color and texture were classified as ruddy or dark in four (9 per cent), as fair in twenty-six (59 per cent), as medium in twelve (27 per cent), and two (5 per cent) were considerably freckled.

Skin reflectance will play a role in the severity of burns produced by the flash technique; thus, we attempted to include as many types of skin as possible in each group studied. Future experiments contemplate the measurement of skin reflectance so that thermal injury may be related to the absorbed heat rather than the heat incident on the skin. Wave lengths below 3,200 A. (most of the ultraviolet) were excluded by a filter in an attempt to simulate atmospheric attenuation of the short wave lengths.

Ages of the group varied from 21 to 31 years, with an average of 25 years. All subjects were in good health prior to and during the experiments as shown from body temperature records and peripheral blood studies. Two of the group had well-controlled diabetes. All individuals had previous scars, but none showed evidence of keloid formation.

THERMAL ENERGY SOURCE

The flash burn in all experiments was inflicted by a twenty-four-inch Army searchlight utilizing a high intensity carbon arc, the radiation being focused on the burn aperture by an ellipsoidal mirror.[2] A uniform burn 1.27 square centimeters in area ($\frac{7}{16}$ inch diameter) was produced by techniques described previously[2]; the incident thermal dose and thermal intensity were accurately determined and controlled. Two types of exposure shutters provided thermal doses which could be delivered at a constant intensity (square wave) or with intensities varying rapidly with time (thermal pulse). Accurate timing of each exposure was electronically controlled.

The area of burn was small since we were using human volunteers. Similar burns involving large confluent areas would heal more slowly; also, it is altogether possible that the same depth burn, if it involved a large area, might even be clinically so-called third degree, and not heal without grafting. Atomic flash burns of extensive area would be accompanied in many cases by blast trauma and whole body irradiation, factors which would complicate the response to burn injury. Consequently, the laboratory findings presented here represent the minimal burn injury to be expected from an atomic bomb.

THE CONDUCT OF THE EXPERIMENT

The subject's skin on the arm from elbow to shoulder was used. All hair present in this area was removed by shaving. The skin was dry and without abrasions. No medication of any type was given. At the time of the burning, the volunteer's arm was placed in position and held firmly there by the physician in charge. This procedure prevented overlapping of burns and restricted the subject's movement due to pain or other reflexes. Burns that blistered or which became raw were covered with nonmedicated strips of dry gauze as a protective from subsequent trauma. Observation of the burns was made frequently dur-

ing the six hours following production of the burn; then daily for one week; three times weekly for one week; two times weekly for one week; and then weekly until healing was complete.

GROUP I. THE INCIDENT DOSE REQUIRED TO PRODUCE FIRST, SECOND, AND THIRD DEGREE BURNS

This group was composed of fourteen volunteers, thirteen men and one woman (blonds four, brunettes six, black hair three, red-haired with freckles one).

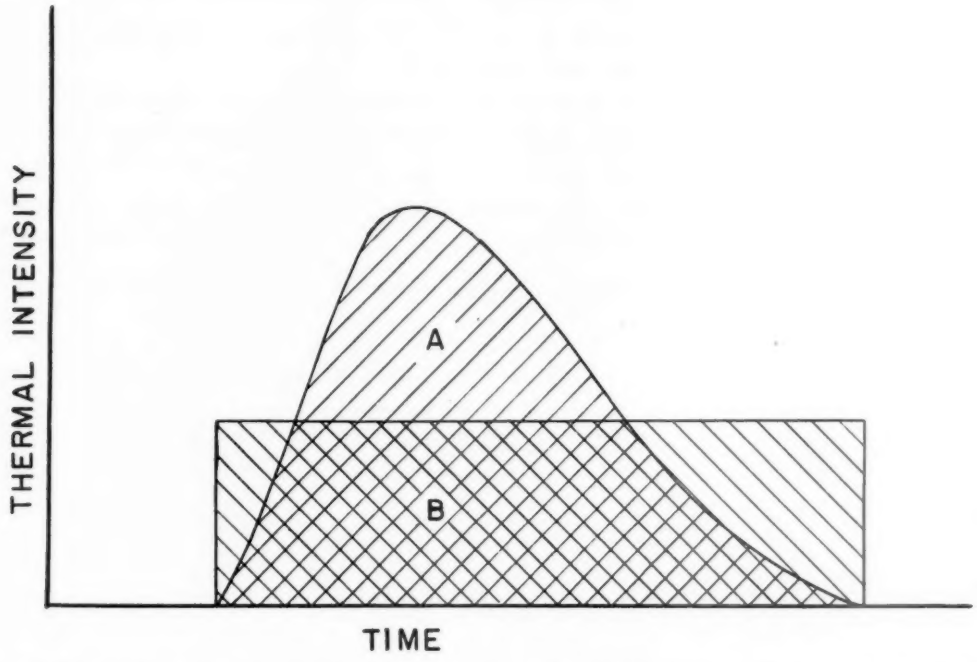

Fig. 1.—Diagram illustrating thermal pulse of radiant energy (*A*) and square wave pulse (*B*). The area under *A* is equal to the area under *B* and represents the integral thermal dose.

Thermal doses of 2.0, 3.2, 3.9, and 4.8 cal. per square centimeter were delivered in approximately 0.54 second by means of a pulse of radiant energy delivered by a special shutter. The thermal intensity attained its maximum value in less than 200 milliseconds, receding more gradually to zero level as illustrated in *A* in Fig. 1. Spectral composition corresponded roughly to the wave lengths emitted by a black body at about 5,800° K. Wave lengths below 3,200 A. were excluded by transmission of the flash through Corning filter 0-53. The spectral quality and time of exposure were held constant while the thermal dose was varied. Each volunteer was given a total of twelve burns; that is, three burns at each of the previously mentioned thermal doses, a total of 168 burns for the group. All burns were made at reasonable distances from each other; this prevented overlapping. Observations were made for six hours immediately after burning and for forty-nine days subsequently. A summary of our observations at each thermal dose level follows:

(a) *2.0 cal. per Square Centimeter Total Thermal Dose.*—There was only transient evidence of mild erythema in three burns of a total of forty-two burns on fourteen different individuals. These three burns, which showed as mild erythema for approximately thirty minutes immediately after the burning, were on one individual who continued to exhibit greater sensitivity than the other volunteers at each dose level. One individual showed reddish pigmentation on the second and third days postburn; this then disappeared. There was no other evidence of any thermal injury at these sites in the subsequent forty-nine days of observation in any of the burned individuals.

A stinging-type pain was experienced immediately by all volunteers; this was described as mild, without significant change of character, and it gradually subsided in a matter of a few seconds to three to four minutes. Two individuals described a sensation of warmth in the area for five to ten minutes after the stinging sensation ceased.

We conclude that thermal doses in excess of 2.0 cal. per square centimeter are required to produce a first degree burn on unprotected human skin in the white race under the given experimental conditions.

(b) *3.2 cal. per Square Centimeter Total Thermal Dose.*—This dose produced almost immediate evidence of burn in all individuals. Thus, in all forty-two burns placed on fourteen volunteer subjects there was immediate mild erythema in the area of the burn. In one burn subject, all three burns showed this mild erythema for only six to eight minutes, after which time all evidence of burn had disappeared, with no subsequent return. Within ten minutes, 93 per cent of individuals showed erythema in the burned area, more intensified with a beginning spread of erythema into the surrounding tissues in some. One subject showed a definite edema in the burn area. At thirty minutes there was pronounced development of the erythema in the surrounding tissues of all subjects, with erythema remaining in the burn area. One hour later, erythema disappeared in the surrounding tissues but remained in the area of the burn. The only significant change noted at four hours was the development of definite edema in the burn area in 28 per cent of the burns. No change from this was observed at six hours. At twenty-four hours the main progression was grossly the presence of edema in 64 per cent of the individuals. One individual (with freckles) had tiny blisters over the freckle spots directly involved in the burn.

Observations on subsequent days showed the burns to follow one of two patterns. In the 36 per cent without edema, the overlying reddish skin became dry and pigmented, well demarcated from the surrounding skin. It usually scaled off, leaving a shiny undersurface of fresh epithelium. There was a halo of very light brown pigmentation around this area, and the surface did not appear contracted nor did it contain scar tissue. This light brown halo of pigmentation persisted throughout the forty-nine days of observation. All of the overlying dry skin fell off between the seventh and tenth days postburn.

In the 64 per cent who showed edema of the skin involved in thermal trauma, about 50 per cent subsequently had small, scattered blisters which developed between one and three days postburn. These tiny accumulations of fluid would

evacuate spontaneously, leaving wrinkled, dry, lightly pigmented skin overlying the burn surface. The subsequent events followed a pattern similar to that outlined previously in the nonedema group. In both groups, reaction surrounding the burn was absent after one day postburn. The halo of light brownish pigmentation with normal inner skin was noted in all subjects. There were no infections and no therapy was given.

Pain was felt immediately and was described as a stinging-burning pain, considered mild by one-half and moderately severe by the other half of the participating volunteers. Duration of pain was from a few minutes to ten to fifteen minutes. Two described the pain as lasting thirty minutes.

The majority of individuals in this group (64 per cent) showed definite mild edema in the area of the burn, and about one-half of these had blister formation. Thus, it appears that 3.2 cal. per square centimeter inflicted under the given experimental conditions resulted in a superficial second degree burn in the majority of subjects studied. In the remaining, it produced a first degree burn. As would be expected, the very light-skinned individuals showed less severe effects.

(c) *3.9 cal. per Square Centimeter Total Thermal Dose.*—There was immediate erythema of the involved skin in all subjects. This gradually became more intense, becoming quite pronounced within five to ten minutes. At thirty-five minutes, 93 per cent of the subjects showed definite edema of the erythematous area, and the erythema spread into the surrounding tissues out as far as 1 cm. from the edge of the burned skin. By two hours and twenty minutes most of the surrounding erythema had disappeared in 50 per cent of individuals; it had completely disappeared in 36 per cent of individuals; one individual had begun to show blister formation. At the fourth hour after burning, blisters had begun to appear in 43 per cent of individuals. In 14 per cent of these, there was a transient return of mild erythema in the surrounding tissues. During the fifth and sixth hours, 50 per cent of all volunteers showed blister formation, while the remainder, except one, demonstrated increasing edema and erythema in the burn area. Blisters were the outstanding feature at twenty-four hours, 86 per cent of the subjects showing them. In over one-half of these, the entire area was replaced by a confluent blister elevated 1 to 2 mm. above the surrounding skin. During subsequent days the blisters emptied of edema fluid either by absorption or trauma, leaving dry, wrinkled, blanched skin overlying the burn with an area of brownish pigmentation present in the outer rim of the burned skin and a surrounding thin rim of erythema in the adjacent skin. As this skin came off it would leave a raw, moist, red, very slightly pitted surface which was rapidly replaced by a dry, dark eschar whose upper level was equal to or slightly above the surrounding skin. By the ninth day, pieces of this eschar had begun to crumble off, leaving pinkish scar tissue.

All eschars and dry pigmented skin were off by the sixteenth day. Observations on the twenty-fourth and forty-ninth days showed the center of the burn site to be pale white with a surrounding halo of light to dark brown pigmentation. Only 21 per cent did not show halo formation on the last day of observation.

The pain was felt immediately after burning by all individuals and described as a stinging-burning sensation, more intense than for either the 2.0 cal. or the 3.2 cal. per square centimeter burns. One-half of the individuals experienced no difference in the character of the pain, while the remainder described a change to a distinctly uncomfortable sensation of warmth in the area. The pain or discomfort lasted somewhat longer than ten minutes but not more than thirty minutes in the majority of individuals. One subject described pain lasting several hours.

All the individuals showed evidence of a second degree burn. Healing was complete in sixteen days, and the burn was still apparent at forty-nine days, as evidenced by pale, shiny epithelium in the center surrounded by a halo of brownish pigmentation having a width of 1 to 3 mm. Little gross evidence could be found to show difference of susceptibility with different skin and hair characteristics, except that complete blister replacement with subsequent deeper raw surfaces was more frequently seen in those groups of individuals classified as dark-skinned. The red-haired, freckled individual showed earlier appearance of blisters which were confined to the darker pigmented area of the freckles. The normal skin between showed only edema and erythema in proportions similar to those exhibited by others with comparable skin texture. The female subject in this group showed a more rapid and more pronounced early reaction as demonstrated by the rather "angry-appearing" erythematous reaction in the surrounding tissues, but the final outcome of her burn lesions was average. No serious infections were encountered, only 14 per cent showing frank pus, which was only transient, two to three days, clearing spontaneously without therapy. The only subjective complaints after the day of injury were those of itching. This was most prominent during the sixth through the fourteenth days postburn. We conclude that a thermal dose of 3.9 cal. per square centimeter under the prescribed conditions will produce a well-defined second degree burn on the exposed tissue of the white race.

(d) *4.8 cal. per Square Centimeter Total Thermal Dose.*—There was immediate blanching of the burned area; this blanching remained constant throughout the first six hours of observation postburn. There was a rapidly appearing and gradually intensifying erythematous reaction in the surrounding areas which was maximum in extent and intensity within thirty to forty minutes. About the time of maximum response in the surrounding tissues, there was a definite formation of edema in the blanched area. This edema was usually evident as an early rim at the periphery which soon became confluent throughout. Pin-point pitted areas representing hair follicles were early in appearance, usually at the time the rim edema was beginning. Blisters first appeared in one individual at two hours, while the other subjects showed increasing edema and persistence of the surrounding erythema. Three individuals had a transient speckled blanching and erythema in the involved skin. Fifty per cent of the individuals displayed blisters by the sixth hour postburn. Some of these were confluent; others were scattered small collections of fluid. The remaining subjects showed continuing blanching of the burn, increasing edema, and persistent, but reduced, erythema, in surrounding tissues. All individuals

displayed blisters at twenty-four hours, with 64 per cent being completely replaced by large confluent blisters. In subsequent days these would lose the blister fluid either by absorption or trauma and leave dry, wrinkled skin overlying or reveal raw, glistening, deeply pitted surfaces. There was generally some pigmentation in the outer rim of affected skin. A rim of slight erythema in the surrounding skin was evident through the fifth day. The burns were then replaced by thick eschars usually extending 1 to 2 mm. above the adjacent normal skin. Occasionally, these eschars would show central pitting. By the ninth day, the eschars gave evidence of contraction with small rims of scaly, pink scar tissue about them. All eschars were off between the twenty-fourth and forty-ninth days of observation, leaving whitish scar tissue centers surrounded by a rim 2 to 3 mm. wide of light brown pigmentation.

The pain was felt immediately by all individuals and was described as sharp and stabbing with an intensity greater than any of the other burns. Over 50 per cent of the individuals experienced complete absence of the pain shortly after the initial shock, lasting for two to three minutes, after which a stinging-burning sensation returned and lasted from minutes in a few to one hour or more in other individuals. No other painful sensations were noted until two to three days later, when 40 per cent of individuals had some pain at the burn sites. This was followed in approximately one week to ten days by itching.

One burn in one individual became badly infected and, after cultures which showed beta *Staphylococcus aureus* sensitive to bacitracin and Aureomycin, was treated locally and systematically with prompt response in twenty-four hours.

All individuals receiving 4.8 cal. per square centimeter under the prescribed physical conditions had deep second degree burns which might possibly be classified as third degree in some cases. In such small areas and without biopsies, it is difficult to differentiate between the deep second degree and third degree burn, but from close observation it seems highly probable that at least 50 per cent were third degree without infection in which healing of such a small area was accomplished in twenty-four days without skin grafting.

TABLE I. CLINICAL ASSAY OF DEGREE OF BURN INJURY PRODUCED BY VARIOUS THERMAL DOSES UNDER THE EXPERIMENTAL CONDITIONS DESCRIBED FOR GROUP I

DOSE FROM THERMAL PULSE IN CAL./CM.^{2}	DEPTH OF BURN (CLINICALLY) ON UNPROTECTED HUMAN SKIN
2.0	None
3.2	First or superficial second degree
3.9	Second degree
4.8	Deep second or third degree

SUMMARY AND DISCUSSION FOR GROUP I

Table I summarizes briefly our observations on Group I. In Fig. 2 we have attempted to relate our findings to the experimental conditions likely to be encountered by personnel exposed to a 20 KT atomic bomb on a day in which the visibility was twelve miles. We have assumed that approximately 70 per cent of the total thermal energy from such a weapon would be liberated during the first one-half second after the explosion, that this thermal energy would

have an average spectral distribution closely corresponding to the carbon arc (5,800° K.), and that only the thermal energy liberated during the first one-half second would be effective in producing thermal injury. On the basis of these assumptions we have indicated in Fig. 2 the approximate slant range from such a weapon at which thermal doses of 2.0, 3.2, 3.9, and 4.8 cal. per square centimeter would be produced. We believe that these flash burns inflicted on Group I represent the minimal damage to exposed tissue in the white race which could be expected from an atomic explosion under the specified conditions.

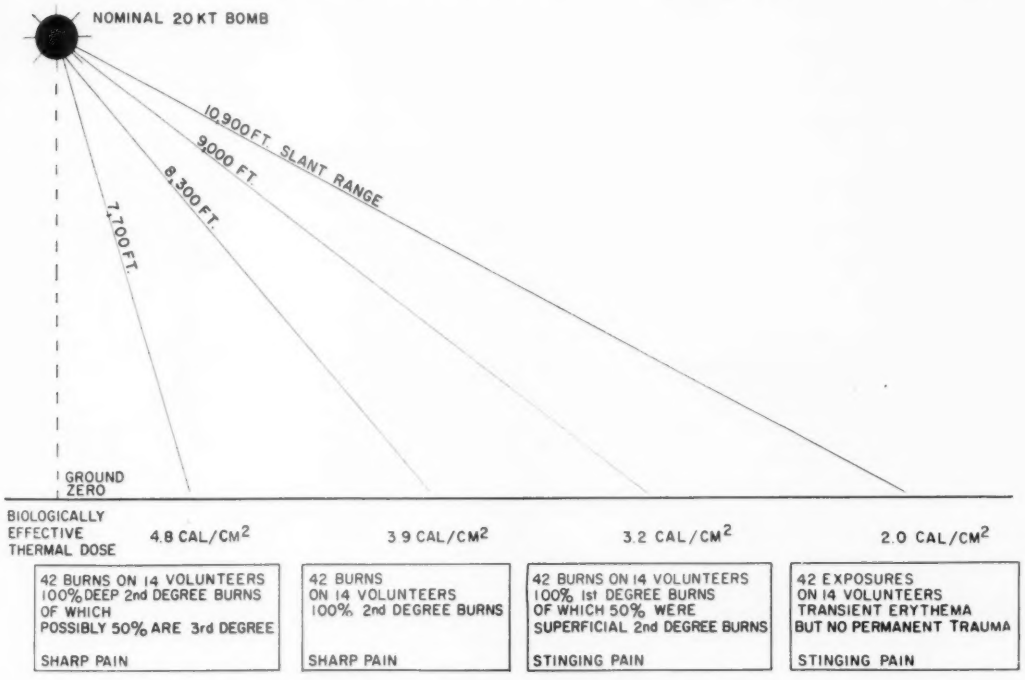
NOMINAL 20 KT BOMB
10,900 FT. SLANT RANGE
9,000 FT.
8,300 FT.
7,700 FT.
GROUND ZERO
BIOLOGICALLY EFFECTIVE THERMAL DOSE
4.8 CAL/CM2
3.9 CAL/CM2
3.2 CAL/CM2
2.0 CAL/CM2
42 BURNS ON 14 VOLUNTEERS 100% DEEP 2nd DEGREE BURNS OF WHICH POSSIBLY 50% ARE 3rd DEGREE
SHARP PAIN
42 BURNS ON 14 VOLUNTEERS 100% 2nd DEGREE BURNS
SHARP PAIN
42 BURNS ON 14 VOLUNTEERS 100% 1st DEGREE BURNS OF WHICH 50% WERE SUPERFICIAL 2nd DEGREE BURNS
STINGING PAIN
42 EXPOSURES ON 14 VOLUNTEERS TRANSIENT ERYTHEMA BUT NO PERMANENT TRAUMA
STINGING PAIN

Fig. 2.—Diagrammatic summary indicating severity of burn lesions which might be expected at various slant ranges from the detonation of a nominal 20 KT atomic bomb on a clear day (visibility of twelve miles). Data represented here were derived from studies in Group I.

We want to emphasize that the pain initiated by these burns, if inflicted simultaneously over large areas of skin (face, neck, arms, and so forth), would be intense and possibly would induce hysterical reactions in most individuals. Our volunteers showed a reflex jerk to pain which occurred in all cases after the thermal dose was delivered. It seems unlikely that any evasive action from an atomic flash would be possible if the major portion of the thermal energy came in one-half second or less.

Data on skin reflectance for the wave lengths used in these experiments would make it possible to relate burn injury to the thermal heat absorbed rather than incident. However, other variables such as individual skin thickness, temperature, and blood supply are also important. Heer[3] has measured the absorption of human skin between 4,300 and 10,100 Å. for black body radiation at various color temperatures. His data show a considerable difference between the white and Negro races for a color temperature of 6,000° K. He found that, on the average, Negro skin would absorb 34 per cent more energy than

white skin. We have recently performed flash burn experiments on twenty-two Negro volunteers who are currently under clinical observation. Equipment is now available for skin reflectance measurements, and such data will be included in our report on Negro volunteers.

GROUP II. THERMAL PULSE BURNS VERSUS BURNS INFLICTED AT CONSTANT THERMAL INTENSITY

A variety of methods for the production of flash burns has been reported.[4] Most investigators have employed shutter mechanisms which expose a limited area to a constant source of thermal intensity for an accurately known time. We refer to this technique as the "square wave" burn or simply the burn inflicted at constant intensity. However, the thermal intensity from an atomic bomb varies rapidly with time, and the question arises as to how well laboratory burns inflicted at constant intensity may be related to burns inflicted by a thermal pulse of radiant energy. Fig. 1 is a schematic representation of the thermal pulse (*A*) and the square wave (*B*). The experiments in Group II were designed to explore the possible differences between the two techniques.

In this comparison, the incident dose, the time of delivery (600 milliseconds), and the spectral quality were held constant while the mode of delivery was controlled by either the pulse shutter or the square wave (constant intensity) shutter. As before, spectral quality corresponded roughly to that emitted by a black body at 5,800° K. minus wave lengths below 3,200 Å.

A total of fifteen volunteers were studied in this group, fourteen men and one woman (blonds two, brunettes nine, black-haired three, red-haired with freckles one). Each student received a total of eight burns. Two burns each at 3.9 cal. and 4.8 cal. per square centimeter using the square wave method of administration and two burns each at 3.9 cal. and 4.8 cal. per square centimeter using the pulse technique, a total of 120 burns, were delivered. Burns were placed adjacent to one another on the same arm for comparison. Very frequent observations were made for six hours on the first day and then daily for forty-two days.

A clinical differentiation between the two types of burn proved difficult to make. However, we were inclined to believe that those burns produced by the pulse shutter were somewhat more severe than those produced by the square wave technique because:

(a) The immediate pain seemed to be more severe.
(b) The erythema was of a more intense red, spread further out into the surrounding tissues, and persisted longer.
(c) The edema appeared sooner and was more pronounced.
(d) The blisters appeared sooner and became larger in size.
(e) Eschar formation was more pronounced and was followed by greater pitting of the resultant scar tissue.

The points of distinction between the two methods of delivery of thermal energy were slight in each instance, and all burns healed at the same rate. Therefore, from a clinical viewpoint these observations denote a trend rather than significant differences in depth of tissue destruction. Whether or not

these differences would become more apparent as larger skin surfaces were involved, we do not know. The trend is toward more severe injury for the burn inflicted by the simulated bomb flash, and this trend is more pronounced immediately after exposure and for the first few hours postburn.

Fig. 3 gives photographs of burn lesions in this group at different stages postburn.

A. *B.* *C.* *D.*

Fig. 3.—Photographs indicating progress of lesions on male subject of Group II. Individual had ruddy texture to skin and numerous freckles. There are two lesions below each mark as follows: *4S* indicates 3.9 cal. per square centimeter by square wave technique in 0.5 second; *4B* indicates 3.9 cal. per square centimeter by pulse wave technique in 0.5 second; *5S* indicates 4.8 cal. per square centimeter by square wave technique in 0.5 second; *5B* indicates 4.8 cal. per square centimeter by pulse wave technique in 0.5 second. *A*, Approximately six hours postburn; *B*, one day postburn; *C*, two days postburn; *D*, nine days postburn.

GROUP III. THE INFLUENCE OF THE THERMAL RATE OF DELIVERY ON THE BURN LESION

Most materials exhibit some type of reciprocity relationship between thermal intensity and time for a given dose. The experiments in Group III were designed to investigate tissue response to a constant dose of thermal radiation when the intensity and time of exposure were varied.

A total of fifteen volunteers were studied in this group, fourteen men and one woman (three blonds and twelve brunettes). A thermal dose of 4.8 cal. per square centimeter was selected, and each student volunteered to receive six burns on the same arm. Spectral quality again corresponded to that emitted by a black body at 5,800° K., minus wave lengths below 3,200 Å. The pulse shutter was used to provide exposure times of 0.5, 0.7, 1.0, 1.4, 2.2, and 3.4 seconds. The shape of the thermal pulse (intensity versus time) and the area under the pulse (thermal dose = intensity in cal./cm.^{2}/sec. × time in sec. = 4.8 cal./cm.^{2}) remained the same for each of the six exposures.

There were ninety burns in all, six on each of fifteen volunteers; observations were made through the thirty-fifth day postburn. In Table II the clinical estimation of degree of burn for the entire group is given for each exposure time.

A. *B.* *C.* *D.* *E.*

Fig. 4.—Photographs illustrating progress of lesions on male subject of Group III. Figures on arm adjacent to lesions indicate time in seconds and fractions thereof required to deliver thermal dose of 4.8 cal. per square centimeter by pulse wave technique; thus, .5 represents 0.5 second. .7 represents 0.7 second, *1.0* represents 1.0 second, and so forth. *A*, Approximately one hour and forty minutes postburn; *B*, one day postburn; *C*, three days postburn; *D*, nine days postburn; *E*, eighteen days postburn. This volunteer had rather deep sunburn, and all lesions were somewhat more severe than in the average. This was especially true in those burns requiring 1.4 seconds or longer for delivery.

The differences in the various burns were clearly evident on each individual's arm and grouped themselves unquestionably as indicated. Fig. 4 illustrates the progress of the burn lesions on a male volunteer in Group III. The clinical course and description of the burns produced followed a plan similar to those already described in the Group I experiments for the various depths of destruction designated.

TABLE II. EFFECT OF THERMAL RATE OF DELIVERY ON SEVERITY OF BURN LESION (4.8 CAL. PER SQUARE CENTIMETER BY THERMAL PULSE SHUTTER)

TIME (SECONDS)	DEGREE OF BURN
0.5	Deep second degree or third degree
0.7	Deep second degree or third degree
1.0	Second degree
1.4	Second degree
2.2	Superficial second degree
3.4	First degree

It is evident that the incident rate of input of radiant energy has a pronounced effect upon the severity of the burn lesion; a dose of 4.8 cal. per square centimeter delivered in 0.5 second produces a deep second or possibly a third degree burn, whereas the same dose delivered in 3.4 seconds produces only a first degree burn. This reciprocity relationship should be allowed for in any attempt to predict the degree of thermal injury at various slant ranges from an atomic explosion. For example, in a 20 KT explosion the fireball will continue to radiate thermal energy at relatively low intensities in appreciable amounts, long after the major proportion of the thermal energy has been dissipated. Instruments which record the integral thermal dose include the thermal radiation in the so-called "infrared tail," but much of this energy will be ineffectual in producing burn injury on exposed human tissue. Furthermore, as will be seen from the data on Group IV volunteers (Influence of Spectral Quality on Thermal Injury), infrared radiation is less effective in producing burns on the exposed skin of white volunteers than the shorter wave lengths. These physical phenomena are the basis for our assumptions used in estimating the effective biologic dose of thermal radiation from a 20 KT bomb in Fig. 2.

It is reasonable to suppose that nuclear weapons larger than 20 KT will liberate their thermal energy over a longer period of time, so that the reciprocity relationship should be borne in mind when trying to assess the thermal potentialities of such weapons. We conclude that the influence of the thermal rate of delivery on the burn lesion is significant in the evaluations of weapons' effects.

GROUP IV. THE INFLUENCE OF SPECTRAL QUALITY ON THERMAL INJURY

There were ten volunteers for this experiment (nine men, one woman; two blonds, seven brunettes, and one with black hair). The carbon arc at an approximate temperature of 5,800° K. served as the source of thermal radiation. The incident dose (3.9 cal. per square centimeter) and the exposure time (0.54 second) were maintained constant throughout the experiment while the spectral quality at each burn exposure was different. This was accomplished by the interposition of appropriate Corning filters between the shutter mechanism and

the burn aperture. Ten filters were used, each volunteer receiving ten burns on the same arm, making a total of 100 burns for clinical observation.

The Corning filters used in this experiment are tabulated in Table III, together with the clinical assessment of the degree of burn for each spectral composition. The transmission characteristics of each filter are indicated in the table. For example, filter 0-53 transmits better than 85 per cent of all wave lengths beyond 3,200 A. but exhibits a sharp cutoff just below this wave length. All the filters listed transmit better than 85 per cent of the radiation beyond their indicated cutoff. In Fig. 5, we have drawn a relative energy density versus wave length curve for a black body at 5,800° K. The area under this curve represents to a fair degree of approximation the total energy emitted by the carbon arc in our experiment. Roughly 50 per cent of the total energy is to be found at wave lengths in the visible and ultraviolet, while the remainder is distributed over the infrared region. Cutoff wave lengths for several typical filters are indicated in Fig. 5. As an example, filter 3-67 transmits 87 per cent of all wave lengths to the right of the dotted line drawn perpendicular to the y axis at 0.565 μ.

TABLE III. EFFECT OF GRADUALLY EXCLUDING WHITE LIGHT FROM THE RADIATION SPECTRUM OF CARBON ARC WITH RESULTANT GREATER PROPORTION OF INFRARED (3.9 CAL. PER SQUARE CENTIMETER IN 0.54 SECOND BY SQUARE WAVE SHUTTER)

Corning filter 0-53 3,200 A. and beyond	Second degree burn
Corning filter 0-52 3,700 A. and beyond	Second degree burn
Corning filter 3-69 5,350 A. and beyond	First degree burn
Corning filter 3-68 5,500 A. and beyond	No burn
Corning filter 3-67 5,650 A. and beyond	No burn
Corning filter 3-66 5,800 A. and beyond	No burn
Corning filter 3-73 5,900 A. and beyond	No burn
Corning filter 2-61 6,250 A. and beyond	No burn
Corning filter 3-58 6,500 A. and beyond	No burn
Corning filter 2-64 6,800 A. and beyond	No burn

Referring again to Table III, we have listed the degree of burn for each spectral composition of wave lengths. No clinical difference was apparent between burns which were produced by wave lengths beyond the filter cutoffs 3,200 and 3,700 Å. Each of these burns on the ten volunteers followed a course similar to that described for 3.9 cal. per square centimeter burns in Group I, and each was classified as second degree burn. However, when wave lengths shorter than 5,350 Å. were excluded from the incident radiation, the burn injury was less severe than when the shorter wave lengths were present. These burns showed an area of pinkish or brownish pigmentation for as long as ten days in 50 per cent of the individuals; in the remaining 50 per cent, this change had disappeared by the second day. The classification was first degree burns.

Exposure to thermal radiation containing only those wave lengths greater than 5,500 Å. resulted in transient erythema which disappeared within five hours in 70 per cent of the volunteers. The female subject in this group showed a tiny area of brownish pigmentation up to twenty-eight days postburn. A similar situation prevailed for wave lengths greater than 5,650 Å., where erythema had disappeared in 90 per cent of the volunteers by five hours postburn. Exposure through the remaining filters produced nothing more than a transient erythema

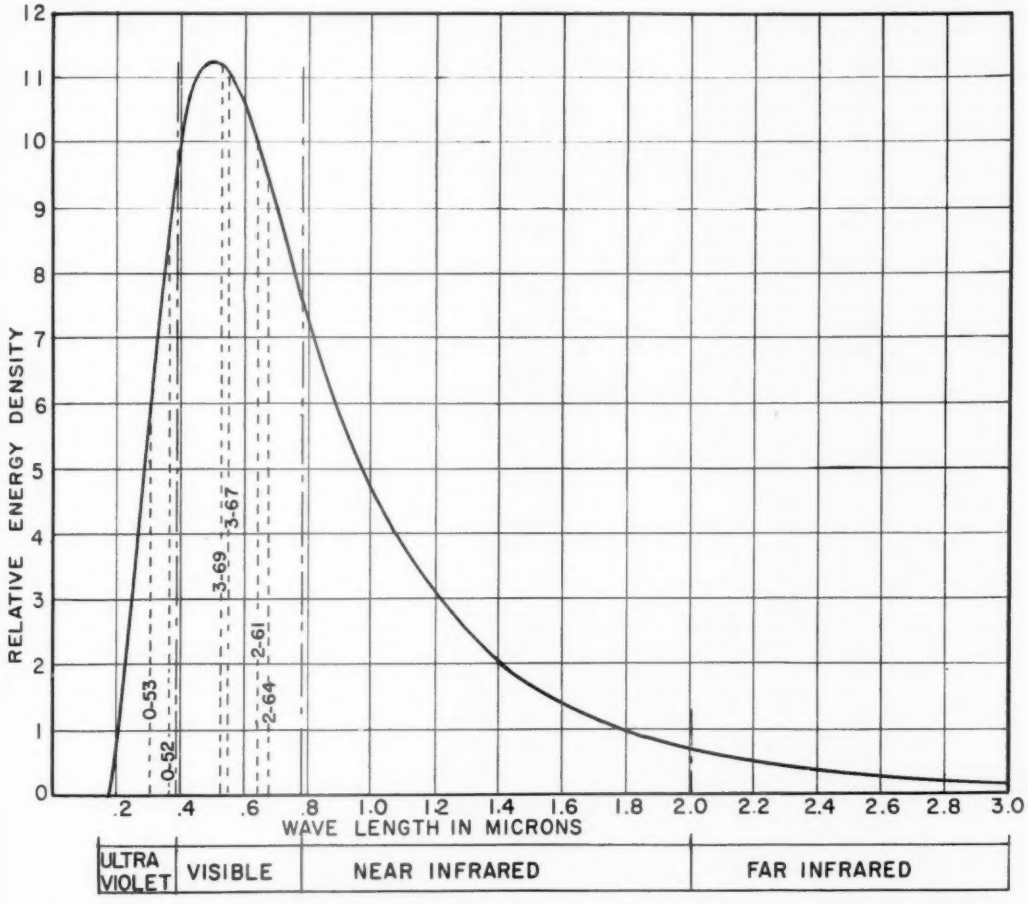

Fig. 5.—The spectral quality of the radiation emitted by a black body at 5,800° K. Energy density in arbitrary units is plotted against wave length in microns. One micron equals 10,000A. The approximate "cutoff" for each Corning filter is indicated by the vertical dotted lines on the diagram. All wave lengths to the right of the line are transmitted at approximately 90 per cent of their original intensity.

lasting from five to thirty minutes with the exception of the last filter used. Exposure to wave lengths greater than 6,800 Å. produced a deep erythema in the burn area for one hour in 80 per cent of the students. This gradually faded until at four and one-half hours postburn, 40 per cent displayed no evidence of thermal injury; all manifestations of burn injury had disappeared by the fifth day. There is evidence that the wave lengths beyond 6,800 Å. may produce more trauma than the intermediate (5,500 to 6,800 Å.) wave lengths. Our spectral resolution was too limited to study this tendency carefully. Fig. 6 illus-

A. *B.* *C.* *D.* *E.*

Fig. 6.—Photographs illustrating progress of lesions on a female subject in Group IV where 3.9 cal. per square centimeter was delivered to all areas indicated in 0.5 second by the square wave technique. Numbers on arm adjacent to lesions indicate Corning filters used in same order as in Table III; thus, *1* represents burn produced by Corning filter 0-52 in place, *2* represents burn produced with Corning filter 0-53 in place, and so forth. Lesions below number 7 could not be visualized for photography. *A*, Approximately twenty-five minutes postburn; *B*, approximately five hours postburn; *C*, one day postburn; *D*, five days postburn; *E*, ten days postburn.

trates the dependence of the burn lesion on wave length for a female volunteer. It is important to note that while none of these 3.9 cal. per square centimeter exposures limited to wave lengths beyond 5,500 Å. produced a clinically recognizable burn, they were quite painful immediately after exposure, perhaps as painful as the burns which included the short wave lengths.

We conclude that the spectral quality of radiant energy incident on exposed tissue in the white race has considerable influence on the severity of the burn lesion. When wave lengths shorter than 5,500 A. are excluded from the carbon arc spectrum, thermal doses in excess of 3.9 cal. per square centimeter are necessary to produce well-defined first degree burns. On the other hand, when these same doses (3.9 cal. per square centimeter) include all wave lengths in the carbon arc beyond 3,200 A. well-defined second degree burns result. Burn trauma is a function, therefore, of spectral quality as well as of thermal dose and thermal rate of delivery.*

GROUP V. THE EFFECT OF SKIN TEMPERATURE ON BURN TRAUMA

A group of eight white volunteers (seven men, one woman; five brunettes and three black-haired) were used to determine the influence of initial surface temperature of the skin on the severity of the burn lesion. Thermal dose (4.8 cal. per square centimeter), exposure time (0.54 second thermal pulse), and spectral quality (all wave lengths beyond 3,200 A.) were held constant during this experiment.

The arm of each volunteer was cooled to approximately 15° C. by means of an ice pack. Skin temperature was measured with a thermocouple constructed in a manner to ensure contact at constant pressure. The first burn was administered at 15° C.; as the arm gradually returned to normal temperature, burns were inflicted at 20° C., 25° C., and 30° C. (normal). Thus, each volunteer received four burns, providing a total of thirty-two burns for the group.

TABLE IV. EFFECT OF LOWERING SKIN SURFACE TEMPERATURES ON RESULTANT THERMAL INJURY (4.8 CAL. PER SQUARE CENTIMETER DELIVERED IN 0.54 SECOND BY PULSE TECHNIQUE)

TEMPERATURE OF SURFACE SKIN (° C.)	CLINICAL ASSESSMENT OF BURN LESION
30 (Normal)	Deep second degree or third degree
25	Second degree
20	Superficial second degree
15	First degree or no burn

Table IV summarizes the clinical results of the experiment. Of the eight burns at 15° C., three exhibited transient erythema, five showed skin pigmentation and suggestive edema or wrinkling of the skin. At 20° C., two volunteers showed only transient erythema, while six exhibited lesions similar to those described for a 3.2 cal. per square centimeter dose in Group I. These were classified as superficial second degree. At 25° C., skin lesions in all volunteers underwent changes similar to those described in Group I for 3.9 cal. per square centi-

*It is interesting to note that heat-sensitive paper (Chemical Corps, Vesicant Detector M6) exhibits a spectral response quite similar to that of tissue.

meter. The burns inflicted at normal skin temperatures were entirely similar to those observed previously in Group I for a 4.8 cal. per square centimeter dose. Fig. 7 illustrates typical lesions in this group.

The results of this experiment are about what would be expected. It seems evident that tissue must be raised to a critical temperature before heat degradation sets in. This is assumed to be at about 45° C. according to some investigators. We did not measure skin temperature during the burn.

A. *B.* *C.*

Fig. 7.—Photographs illustrating progress of lesions on a male subject of Group V in whom 4.8 cal. per square centimeter was delivered in 0.5 second to all areas indicated by the pulse wave technique. Numbers on the arm indicate the following: *1*, a skin surface temperature at the time of thermal exposure of 15° C.; *2*, a skin temperature of 20° C.; *3*, a skin temperature of 25° C.; *4*, a skin temperature normal for the individual. *A*, Approximately thirty minutes postburn; *B*, one day postburn; *C*, six days postburn.

SUMMARY

Flash burns were produced on forty-four white volunteers by means of a carbon arc operated at high current density. A total of 510 individual flash burns were inflicted on the upper arms of the subjects. Special emphasis was placed upon the physical characteristics (thermal dose, thermal intensity versus time, thermal dose rate, spectral composition, surface skin temperature) accompanying exposure in an attempt to collect data which would be of value in assessing thermal injury likely to be produced by an atomic explosion. Conclusions are as follows:

1. Thermal doses in excess of 2.0 cal. per square centimeter must be incident on exposed tissue to produce a first degree burn; 3.2 cal. per square centimeter produces superficial second degree burns; 3.9 cal. per square centimeter produces well-defined second degree burns; 4.8 cal. per square centimeter produces deep second degree burns and possibly third degree burns. The conditions of exposure were grossly similar to those likely to be encountered at slant ranges of 10,900, 9,000, 8,300 and 7,700 feet, respectively, from a 20 KT bomb exploded on a clear day (visibility twelve miles).

2. Burns inflicted by a thermal pulse in which the intensity varied rapidly with time were more severe during the immediate postburn period than burns inflicted by a constant thermal intensity over the same exposure time. However, the clinical effects were not markedly different when followed over a period of several weeks. Flash burns produced at constant thermal intensity seem roughly comparable to thermal pulse burns within the limits studied here.

3. Thermal doses of 4.8 cal. per square centimeter delivered to the burn area in 0.5 second produced deep second or third degree burns. When these same doses were delivered with increasing exposure times, the severity of the burn lesions decreased. In the extreme case of a three-second exposure time, only first degree burns were produced. The thermal rate of delivery has a pronounced effect on the severity of the burn lesion.

4. Thermal exposures which included the entire carbon arc spectrum beyond 3,200 Å. produced more severe burns than physically equivalent exposures which excluded all wave lengths shorter than 5,500 Å. Flash exposures which included all wave lengths beyond 3,200 Å. produced deep second or third degree burns for thermal doses of 4.8 cal. per square centimeter, whereas only first degree burns resulted from exposures to 4.8 cal. per square centimeter when wave lengths shorter than 5,500 Å. were excluded from the spectrum. The spectral composition of the incident radiation is an important factor in the production of the burn lesion.

5. Thermal exposures at skin temperatures of 15°, 20°, 25°, and 30° C. produced burns of increasing severity as the skin approached normal temperature.

6. These experiments emphasize the importance of physical factors in the production of flash burns. In particular, we believe that the thermal rate of delivery and the spectral composition of the incident radiation are important factors influencing the effective thermal dose delivered by a nuclear weapon. We estimate that approximately 70 per cent of the total or integral thermal dose from a 20 KT bomb will be effective in producing burn trauma on the exposed tissue of a white population. It is reasonable to expect that larger weapons than this will require a longer time to release their thermal energy, and this implies that the biologically effective thermal dose will be a smaller percentage of the total dose delivered.

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Surgical History

CONDUCTED BY JOHN R. PAINE, M.D.

MEDICINE AND SURGERY A.D. 600-1600; THE REBIRTH OF THE MEDICAL PROFESSION IN WESTERN EUROPE

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MY INTEREST is that of an historian whose task it is to patrol the history of Western Europe from A.D. 300 to 1600 watching all the activities of society of which the practice of medicine is not the least important. At the beginning of my chronological journey the medical profession is one of great dignity and honor. It is possessed of a vast literature accumulated over a thousand years. Hippocrates, who was born about 460 B.C., had many antecedent writings to help him, and Galen, who died A.D. 201, over 600 years later, left voluminous works. Dioscorides, who had assembled all previous knowledge of plant, animal, and mineral medicines, had already become the standard authority in pharmacology. These works on medicine were supplemented by the scientific writings of such scholars as Aristotle, Pliny, and Ptolemy. I have mentioned only the most distinguished authors, whose works form only a part of the accumulated literature on these subjects. These were available throughout the Roman world in A.D. 300 and there were distinguished teachers and flourishing medical schools. By A.D. 600 there was no medical profession in Western Europe. Why?

The Roman Empire had begun to decline in power. It had failed to solve the problem of peaceful succession in the imperial office. The military power fell into the hands of mercenaries recruited from the barbarian tribes. No real attempts were made to Romanize these soldiers, and eventually the officer corps itself consisted wholly of barbarian chiefs. Another unfortunate development arose from the imperial adoption of Christianity as a state religion. In the great division of opinion over the nature of the Trinity, the Arians were declared heterodox and were persecuted. Many of these Arians sought refuge among the barbarian tribes whom they converted to their form of Christianity. This led to the anomalous situation that the soldiers upon whom the Empire depended were legally outlaws. In the contact between these Arian troops and the more numerous orthodox Christians of the Empire, the Arians were gradually being converted and would in the course of time all be won, as happened in Spain. But the Emperor Justinian, who fancied himself a theologian, became impatient and embarked upon a series of ruinous wars in Africa, Italy, and Spain. These wars dragged on for over twenty

Presented at the quarterly History of Medicine Seminar, Department of Surgery, April 5, 1954.

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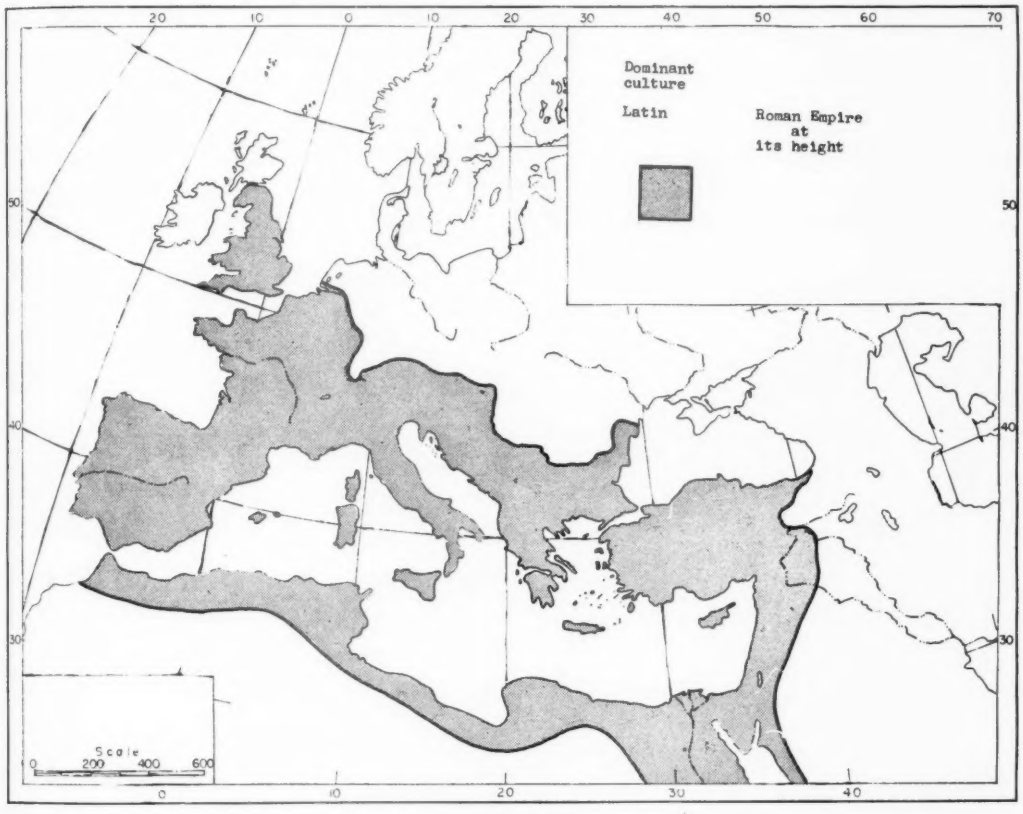
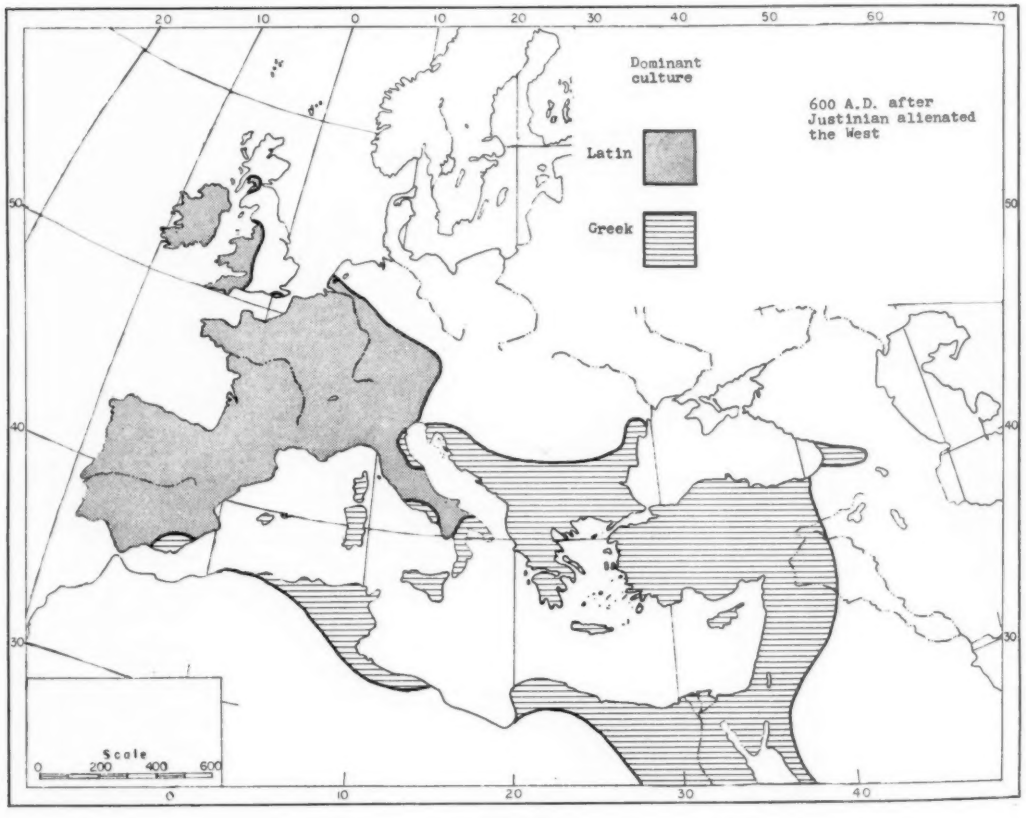
years. The upshot was that the West was alienated from the East, and the Roman Empire, which had been centered at Constantinople ever since the time of Constantine, was barely strong enough to hold its own in a suicidal war with Persia. This war, ending in 628, left the contestants so thoroughly weakened that they fell easy prey to the new Arab Empire just started by Muhammad.



Map 1.

Life in Western Europe rapidly degenerated under a semibarbaric military caste whose every captain sought to make himself an autonomous ruler, and neighborhood warfare became the rule. There is no evidence of hostility to the profession of medicine nor of any conscious effort to destroy the vast literature in which the accumulated medical knowledge was preserved, but by A.D. 600 practically no layman could read. Thus without conscious intent on anyone's part, the medical profession died in Western Europe. Gregory, bishop of Tours, probably the most learned man in all Gaul, has left an account of a personal experience which epitomizes the low point to which medical practice had descended. He had suffered a severe toothache and appealed to two physicians for help without avail. Finally he went to the tomb of St. Martin, scraped some of the dust from the top of the tomb, and applied it to his tooth and gained almost immediate relief.

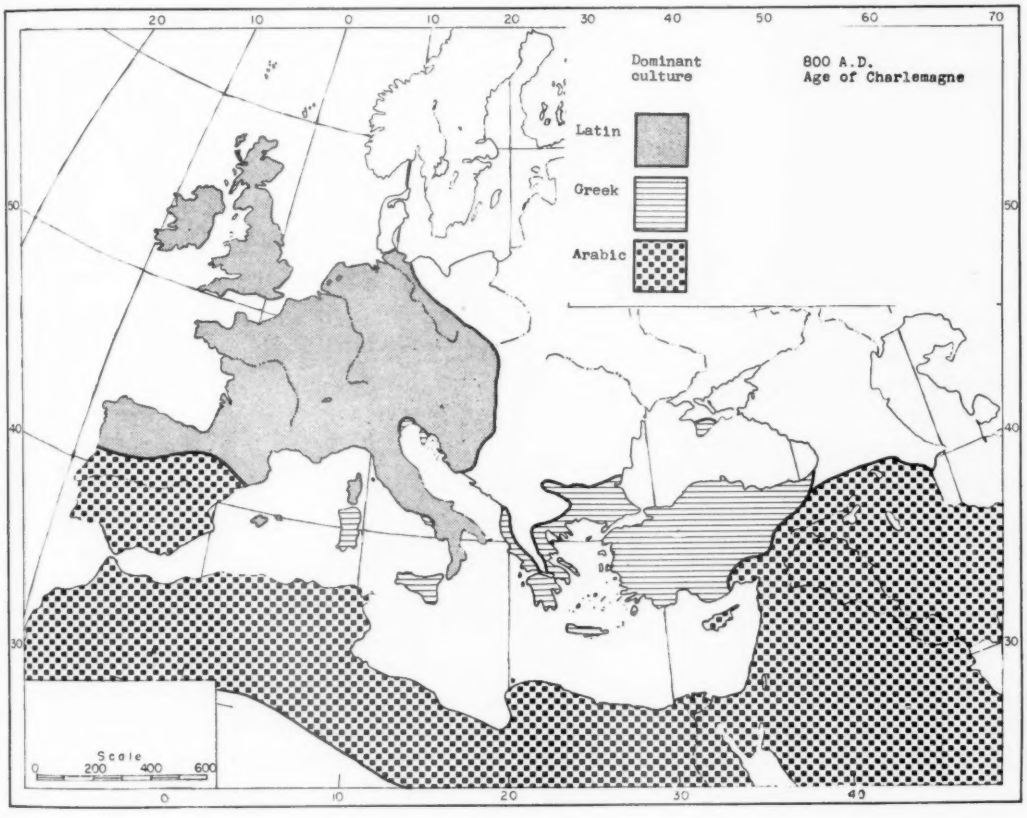
Isidore of Seville, the most learned man in Spain, whose Etymologiae served as the standard encyclopedia for Western Europe for many centuries, included a brief section on medicine. In this section he posed the question of why medicine was not included among the liberal arts and answered it by saying that "the liberal disciplines embrace separate subjects whereas medicine embraces all. He, the physician, must know grammar . . . rhetoric . . . logic . . . arithmetic . . . geometry . . . music [here he cited David's cure of Saul from an unclean spirit and Aesculapius' cure of one subject with frenzy] and astronomy . . . because our bodies change, too, along with the qualities of the heavens." Hence "medicine is called a second philosophy for as the soul is cured by the first (theology) so is the body by the other for both disciplines claim the whole man."[1] This is certainly a high tribute to the profession, but in Isidore's day it was merely a reminiscence and many centuries were to pass before it again became a fact, but this statement helped to keep alive a pleasant memory and a hope.



Map 2.

The one bright ray of hope for the ultimate revival of the medical profession was afforded by the fact that so large a portion of the people of Western Europe had been won to at least a nominal acceptance of Christianity. The language of Western Christianity was Latin; the Bible, the service books, and the commentaries by the great church fathers were all written in that

language. The church officials therefore took over the task of educating their priests sufficiently to be able to carry on the services. Providentially, St. Benedict of Monte Cassino had devised a rule for the government of communities of deeply devout Christians which was capable of survival even under the worst conditions. These communities afforded shelter spots in which education was still possible. These two factors, that the language of Christianity was Latin and that Benedictine monasticism was already founded before A.D. 601, were of vital importance.



Map 3.

For a century and a half after A.D. 600 conditions went from bad to worse. Then for a century the Carolingian line produced four strong rulers in succession who not only brought peace and security to Frankland but extended their empire north and east and south. Many monasteries sprang up; learning was again encouraged. Charlemagne encouraged the laity to take up learning. Physicians are again mentioned. Einhard, Charlemagne's secretary and biographer, recorded that in later life Charlemagne came to hate his physicians. Who these physicians were and how they were trained is not explained.

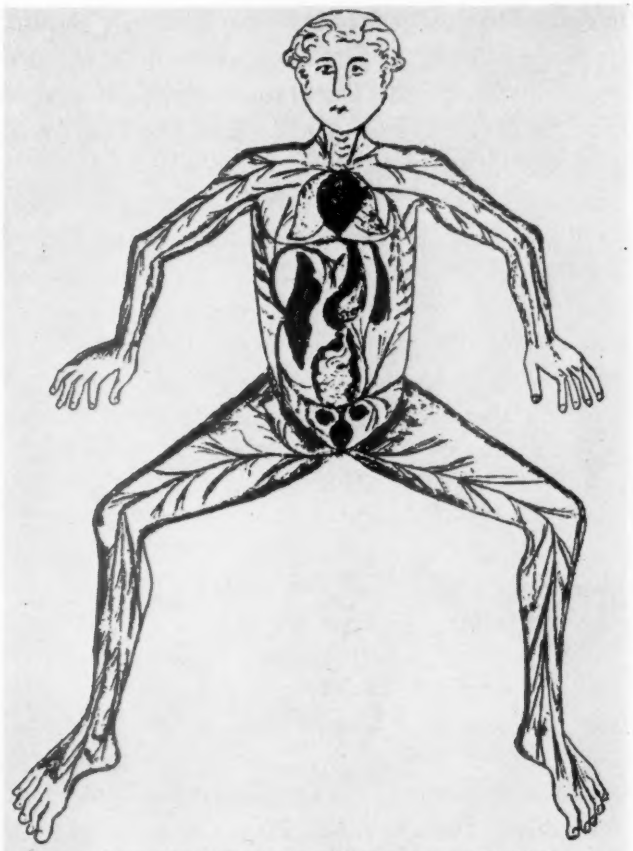
But this Carolingian Empire afforded only a brief respite. Charlemagne's descendants lacked the strength of their forebears. The military caste took advantage of this to gain local independence. Political disintegration was

made more rapid by the Viking raids which affected all the seaboard of Western Europe. Muslim pirates from Africa raided Italy and South France. A new Asiatic migration of Hungarians raided up the Danube valley, and Slavs pressed in from the northeast. Heathens all, they found the churches and monasteries especially attractive plunder and thus destroyed much of the civilization built up by the Carolingian Empire. The British Isles were hardest hit but only a little more than Western France, Italy, and Eastern Germany. Thus was inaugurated the iron age of feudalism which lasted for nearly two centuries, A.D. 850 to 1050. Such medicine as was practiced was strictly of the homemade variety; obstetrics and pediatrics were the concern of the wise women of the neighborhood; surgery was practiced by the man in the neighborhood most skillful with a knife. We get some notion of what this medicine was like from that curious volume in the English Rolls Series entitled "Anglo-Saxon Leechdoms, star-craft and wort-cunning"; "wort," of course, being the Anglo-Saxon term for roots and included herbs or "yarbs."

A few rays of light began to appear in this darkest part of the Middle Ages toward the second half of the tenth century. A strong line of rulers in German Saxony brought peace to a considerable portion of Europe. The Vikings, having become converted to the Christian religion, promised soon to become zealous protectors rather than destroyers of civilization. In Southern France toward the end of the century a local church council had the courage to enact the "Peace of God," threatening with eternal damnation anyone who broke into a church, robbed the poor, or beat up the clergy. Having some success with this enactment, another church council shortly afterward enacted another measure called the "Truce of God," which forbade the practice of neighborhood warfare from Saturday noon to Monday morning under pain of eternal damnation. Monasteries were reformed and they sought to maintain their standards by some degree of affiliation such as the Congregation of Cluny, which ultimately had several hundred monasteries affiliated with the mother house of Cluny. There was even progress in the study of medicine. The rule of St. Benedict required its followers to take care of the sick. Usually this involved only the community and its immediate neighborhood because each monastery was a purely local institution. The monks supplemented their spiritual remedies with such more material remedies as they could discover. Most of them cultivated medicinal plants, and even acquired books on healing, where possible.

One such instance is recorded by the Monk Richer of Rheims in the year 991. Heribrand, a member of the cathedral Chapter of Chartres, had acquired a copy of the Aphorisms of Hippocrates which he invited Richer to come and read with him. That journey, which would take little more than two hours by automobile today, took him three harrowing days. There, "I entered diligently into the study of the Aphorisms of Hippocrates with my master Heribrand, a man of much culture and learning. But in this work I learned only the ordinary symptoms of diseases and such knowledge of ailments not being sufficient for my desires, I begged him to read with me the book on the concord of Hippocrates, Galen and Soranus. He granted my request for he was

a very skillful man in his art and well acquainted with pharmaceutics, botany and surgery.''[2] Think of one book—a very little one at that—combining the lore of Hippocrates, Galen, and Soranus! Even the Aphorisms which he had read with Heribrand was only an epitome. But it did indicate some progress.



Arterial System, from a Late Thirteenth-Century Provençal MS (D. II. 11.) in the Basel University Library
(From Sudhoff, *Geschichte der Anatomie im Mittelalter*, Leipzig, 1909, Plate V)

Fig. 1.—This is an illustration of the vascular system taken from a French manuscript of about 1250. This is one example of a group of traditional illustrations which were widely circulated throughout the Latin and Arab worlds and are believed to be based upon a series of anatomic sketches from the school at Alexandria. (Chouland, Ludwig: History and Bibliography of Anatomic Illustration, The University of Chicago Press, Chicago, 1920.)

These fingers of light fused together into full dawn when the reformed monks and clergy regained control of the papal office and ensured unified leadership over the whole of Latin Christendom about 1050. This drive for reform had started north of the Alps and acquired terrific momentum. The "Pax Dei" and the "Treuga Dei" spread widely. The provision of both enactments, so modest at first, had been expanded to include the protection of women, orphans, peasants, and merchants under the first and had extended the prohibition of neighborhood warfare from Thursday to Monday. The local variations in the conduct of church services and practices which had

developed under feudalism were being eliminated, and the ideas of one unified and uniform church under the firm headship of the Pope at Rome had become the battle cry of the reform party. In Southern Italy the reformed party encountered some communities of Greek Christians who regarded Constantinople as their head. The centuries of separation had resulted in the development of some important differences between the Greek and Latin Christians. It was only logical that the reform party which had ironed out so many local differences in the West should undertake to eliminate these differences also. Negotiations were undertaken with Constantinople looking toward the unification of all Christendom under the headship of the Pope at Rome. Although the Greeks were not at all willing to accept the headship of the Pope, the rising power of the Turks led them to invite the cooperation of the West. This was accomplished in 1095 when Pope Urban II launched the First Crusade for the rescue of the Christian churches in the East. Thus intimate contact between East and West, which had been broken in the sixth century, was effectively re-established in the twelfth century. The importance of the resumption of this connection with the East is hard to overestimate.

In the East during these centuries the knowledge of medicine never sank as low as it did in western Europe. The tradition of learning was too deeply rooted. Constantinople survived successive attacks by the Arabs and preserved its libraries. The Greeks who peopled it had a high regard for learning. So, too, did the Nestorian Christians and the Jews of Syria. Even the Arabs respected learning. Once firmly in control of a vast empire, the Muslims supported learning and the great kalifs, including Haroun-al-Raschid, had camel caravans laden with Greek and Latin books brought to Bagdad where Nestorians and Jews translated these works into Arabic. Great schools arose at Bagdad, at Cairo and finally at Cordova in Spain. Next to the Koran, medicine was a favorite subject of advanced study, for the lusty pleasure-loving Arab rulers were most anxious to prolong their enjoyment of life as long as possible and the advance of medical knowledge seemed to be the surest means to that goal. They not only helped to preserve the ancient knowledge of medicine but made important additions to it.

What this resumption of contact with the East might mean for the West had already been foreshadowed by what happened in Salerno, famous for its healing waters. The improvement in the condition of Western society, the lessening of neighborhood warfare, the increase in trade, the resumption of money economy made possible wider and more frequent travel. The hybrid descendants of the Northmen, the Normans, inherited all the vigor of their Viking forebears. Having adopted Christianity, their urge for travel was given the additional impulse of pious pilgrimage to the Holy Land. They had become masters of Southern Italy and Sicily. The population over which they ruled was heterogeneous, including Greeks, Jews, and even Muslims, as well as Latins. Being practical-minded they developed a policy of tolerance toward all these subjects; Salerno, which lay within their territory, again became a health resort for those who could afford it. Some brought doctors with them, and we

find these doctors with their apprentices interchanging information. There grew up there in the eleventh century an informal school of medicine. The Normans, who kept in touch with their relatives in France and England, soon came to realize that educated physicians could be more helpful than the uneducated. Montpellier in Southern France had a similar although less spectacular development. There, too, the rulers practiced tolerance, and learned doctors of Jewish or Arab background became the nucleus around which a medical school grew up.

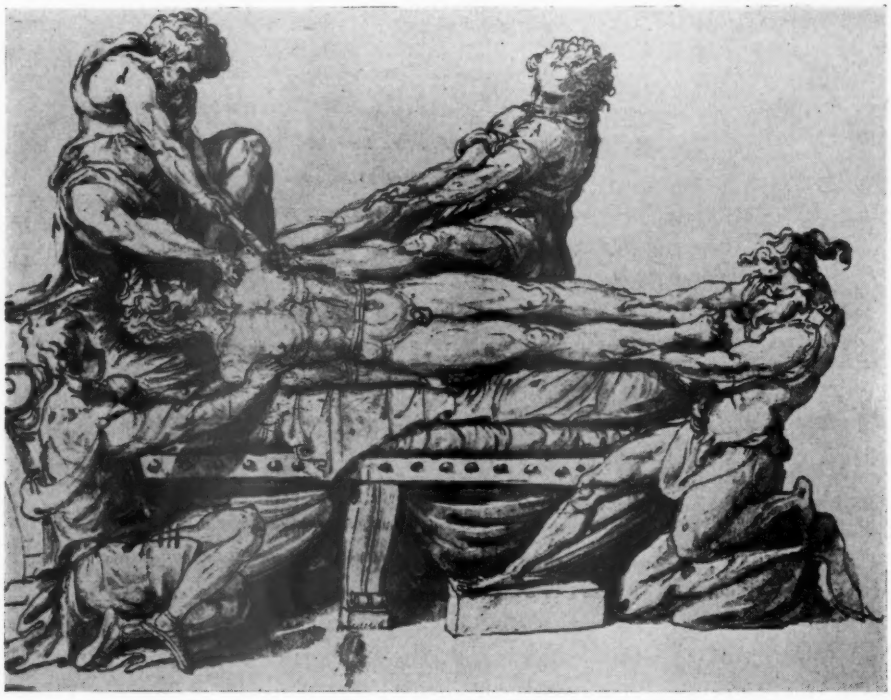


Fig. 2.—This classic illustration showing the reduction of a dislocation of the shoulder by the Hippocratic method is reproduced from a sixteenth century French manuscript of Hippocrates which was based upon a Greek manuscript of the tenth century. This is an excellent example of the manner in which the knowledge of ancient Greece was passed on to the Western Europeans. (Collection de Chirurgiens Grecs, Reproduction du Manuscrit Latin 6866, Bibliothèque Nationale, Département des Manuscrits, Berthaud Frères, Paris.)

The astounding success of the First Crusade in its capture of Edessa, Antioch, and Jerusalem and the establishment of Latin states in Syria won all Latin Christendom to acceptance of the leadership of the church. Crusaders, pilgrims, and merchants could now travel in relative safety from the most remote parts of the West to the Holy Land, and did so. With all this came a tremendous quickening of the peaceful activities of society, agriculture, commerce, industry, building. The church, which had done so much to cut down the amount of neighborhood warfare, now did as much to substitute law for force in the settlement of disputes. More men of learning were required and schools became crowded with students, not all of whom intended to become clergy. Some after studying the liberal arts went off to Bologna to study law, while still others went to Salerno or Montpellier to study medicine. The courts

of kings, princes, prelates, and towns bid for the services of educated physicians. Physicians became quite numerous by the middle of the century, and in some places, as in Florence, they organized themselves into guilds. And thus we again have an organized medical profession in Western Europe.

SAINT JEAN GUALBERT DÉLIVRE DU DIABLE UN MOINE MALADE

D'après une peinture sur bois attribuée à Simone Memmi.

Fig. 3.—Medicine as practiced in the monasteries during the Middle Ages. This painting shows Saint Jean Gualbert (died July 12, 1073) healing a sick monk by exorcising a devil from him. The devil can be seen leaving by the window. The fact that one monk is preparing medicines while a large group are praying shows the relative importance of the two methods of treatment at this time. (Charcot, J. M., and Richer, Paul: Les Démoniaques dans l'Art, Delahaye, Adrien, and Lecrosnier, Emile, Paris, 1887.)

The quality of the medicine which they practiced, however, left much to be desired even in such favored regions as the Holy Land where there was contact with the best of Eastern Medicine. We have the following description of practice there from two scholars, one an Arab, the other a Latin archbishop, both of whom flourished there in the second half of the twelfth century:

> "'They brought before me a knight in whose leg an abscess had grown and then a woman afflicted with imbecility. To the knight I applied a small poultice until the abscess opened and became well; and the woman I put on a diet and made her humor wet.' Then a Frankish physician came to them, and said, 'This man knows nothing about treating them.' He said to the knight 'Which wouldst thou prefer, living with one leg or dying with two?' The latter replied 'Living with one leg.' The physician said 'bring me a strong knight and a sharp axe.' A knight came with the axe. And I was standing by. Then the physician laid the leg of the patient on a block of wood and bade the knight strike his leg with axe and chop it off with one blow. Accordingly he struck it —while I was looking on, but the leg was not severed. He dealt another blow, upon which the marrow flowed out and the patient died on the spot. He then examined the woman and said 'This is a woman in whose head there is a devil which has possessed her. Shave off her hair'—Her imbecility took a turn for the worse. The physician then said 'The devil has penetrated through her head.'

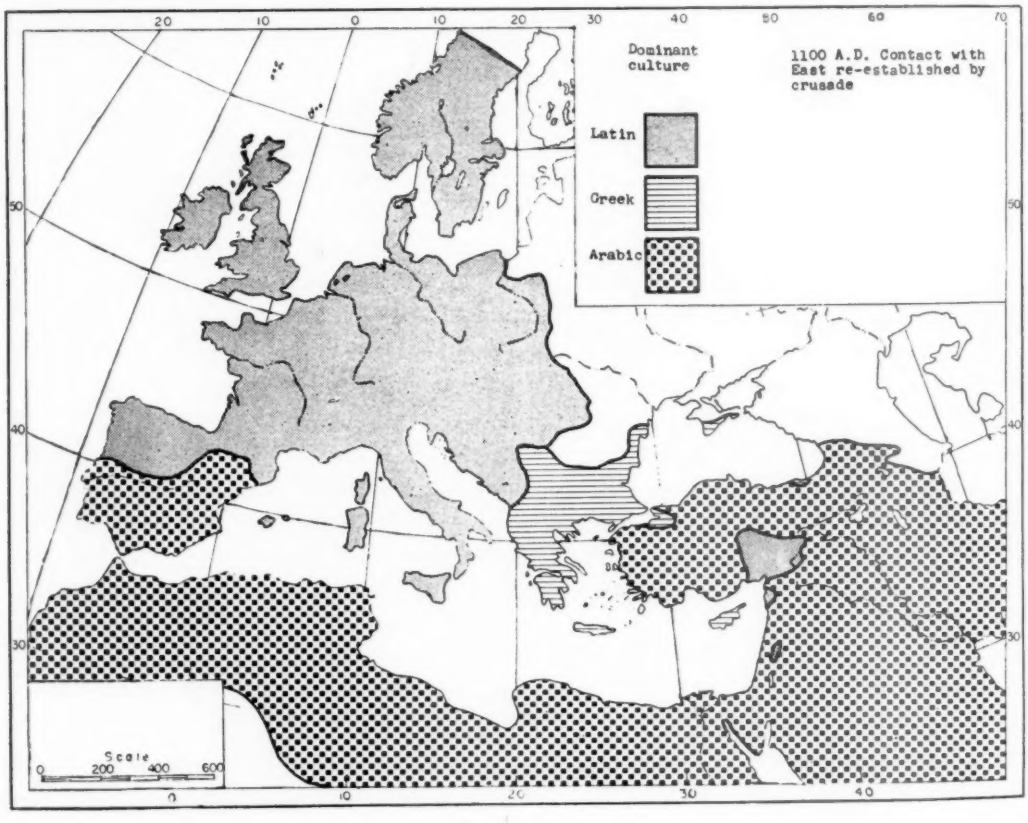
He, therefore, took a sharp razor, made a deep cruciform incision in it, pulled off the skin at the middle of the incision until the bone of the skull was exposed and rubbed it with salt. The woman also expired instantly.''[3]

William, Archbishop of Tyre, made this comment on the relative merits of Eastern and Latin medicine. ''The King of Jerusalem, Baldwin III, desiring to take a physic before the approach of winter, as was his custom, he obtained certain pills from Barac, the physician of the count (of Tripoli) a part of which were to be taken at once and the rest after a short interval. For our Eastern princes, through the influence of their women, scorn the medicines and practices of our Latin Physicians and believe only in the Jews, Samaritans, Syrians and Saracens. Most recklessly they put themselves under the care of such practitioners and trust their lives to people who are ignorant of the science of medicine. It was rumored that these pills were poisoned (they tried the rest of the medicine on a dog who died within a few days). As soon as the king had taken the pills he was seized with a fever and dysentery which developed into consumption from which he never recovered.'' King Baldwin was succeeded on the throne by his brother Amaury. ''Amaury suffered a severe attack of dysentery—and a violent fever came on, although the dysentery yielded to the physicians' skill. After suffering intolerably from the fever for several days he ordered physicians of Greek, Syrian and other nations noted for skill in diseases to be called and insisted that they give him some purgative remedy. As they would not consent to this he had Latin physicians called and made the same request of them adding that whatever the result might be he would take the responsibility upon himself.'' He did. He died.[4]

While these quotations indicate that medical knowledge was still far from what it had been in ancient Roman days, they do reveal the presence of a recognized profession. By the end of the twelfth century and the beginning of the thirteenth century so many students had congregated at Paris and Bologna as to necessitate the organization of universities at these places apart from monasteries and bishoprics. Within them appeared four faculties, arts, theology, law, and medicine. Montpellier, which already had a medical school, added the other faculties and became a university. All were educating physicians. The supply, however, was still lagging far behind the demand and afforded extraordinary opportunities for charlatans, quacks, and imposters of all kinds to carry on very profitable fraud. Snake oil and cure-all vendors were to be found at the fairs, market places, and in the towns. Fraud also appeared in the field of supernatural healing. The possession of the Holy Land afforded a rich field for the acquisition of sacred relics, and the trade in these relics became an important and profitable form of commerce. Pious pilgrims in quest of health or the easing of their consciences were favorite prey for fraudulent vendors of relics. Glib imposters sold rusty nails, splinters of wood, and bones of doubtful origin to the credulous along the pilgrim highways.

The problems of the medical profession were much more complex. As early as 1140 the ruler of the two Sicilies in which Salerno was located enacted requirements for the licensing of physicians. By the end of the century there

were enough physicians to justify the prohibition of practice of surgery by the clergy. Sharper definitions of the relations of apothecaries, leeches, barber-surgeons, wise women, and midwives to the practice of medicine were enacted. With the establishment of the universities and the guilds of physicians, the requirements for a medical degree and a license to practice were raised higher and higher. If you regard the present requirements as rather trying, let me call your attention to those laid down by the Emperor Fredrick II in 1240 for those who would practice in his kingdom of the Sicilies: ". . . an Arts course of three years to the baccalaureate, then five years in the medical school, followed by a year of practice with a reputable physician, another year if the candidate desired to practice surgery as well as medicine." Ten all told. That was not all. He must then present letters of recommendation from physicians and present himself for examination. If successful, he was authorized by the ruler to practice. Only such were legally permitted to practice medicine and surgery in that region.[5]



Map 4.

By the end of the thirteenth century and the beginning of the fourteenth century, we find famous teachers and a growing body of writings on medicine and surgery; Mondino, whose book on Anatomy was to become the standard text on that subject; Pietro d'Abano, who was not only recognized in his own

day as the greatest Latin authority in medicine, but who also spent some years in Constantinople learning Greek and bringing back with him to Padua a number of Greek classics in medicine; and Guy de Chauliac, professor at the medical school of Montpellier and personal physician of the Popes at nearby Avignon. This accumulation of writings by Western medical scholars continued at a fairly rapid pace until the middle of the fourteenth century when the Black Death appeared in Europe.

The Black Death gave a severe setback to medicine. Too few physicians had the courage of Guy de Chauliac, who was ministering to the Pope Clement VI at the time. "So contagious was the disease, especially that with blood-spitting, that no one could approach or even see a patient without taking the disease. The father did not visit the son, nor the son the father. Charity was dead and hope abandoned. For self-preservation there was nothing better than to flee the region before becoming infected and to purge oneself with pills of aloes, to diminish the blood by phlebotomy and to purify the air by fire and to comfort the heart with senna and things of good odor and to sooth the humors with Armenian bele and resist putrefaction by means of acid things. For the cure, bleedings, evacuations and electuaries and cordials were used. The external swelling were softened with figs and cooked onions, peeled and mixed with yeast and butter, then opened and treated like ulcers. Carbuncles were cupped scarified and cauterized. As for me, in order to avoid infamy, I did not dare absent myself, but with continuous fear preserved myself so that I was able to apply the above said remedies; nevertheless, toward the end of the epidemic I fell ill with a continuous fever and a swelling in the groin and was ill for six weeks. I was in such danger that my companions believed that I would die, but the abscess became ripe and was treated as I have said and I escaped by the grace of God."[6] He brought Pope Clement safely through the epidemic, and a part of his treatment was to keep the Pope within an area completely surrounded by charcoal burners. He did it doubtless to purify the air by fire—but it certainly helped to keep rats and their fleas away from the Pope. Few physicians had the courage of Guy. Most of the people were left unattended and the plague swept away a large fraction of the population. Many of the laity who survived hated the profession for this and Petrarch, the most famous literary figure of the time, who had lost his beloved Laura, his chief benefactor, the Cardinal Colonna, as well as many other friends, was especially bitter. He wrote numerous letters denouncing the whole profession. "With them—not as with other trades—it is sufficient to be called a physician to be believed to the last word and yet a physician's lie harbours more danger than any other." He was willing to urge that society get along without physicians and quoted Cato to the effect that Rome had got along well without them for 600 years.[7]

The learned explanation of the Black Death was that it was due to the conjunction of Jupiter, Saturn, and Mars three years before, but within less than a generation after its first appearance in the West the physicians of Ragusa suspected that the ships from overseas with sick passengers or crew might have had something to do with it. The physicians of Marseilles came to

the same conclusion shortly after this, and were soon followed by those of Venice, thus inaugurating the practice of quarantine for all sick or suspected persons on incoming ships. Thorndike, Sarton, and Singer have all remarked on the fact that no notable contributions were made to medical literature for more than a century after the Black Death. Thorndike blamed this failure to advance on the humanists like Petrarch and his followers. My own conviction is that the profession had made about as much progress as it could with the means it had at hand. Books were written by hand; copies were expensive. Time and time again advance had been made in medical knowledge only to be lost or to be known only to a few who did not pass on the information. The chief books of ancient medicine were nearly all written in ancient Greek, those of the Arab and Jewish physicians in Arabic and Hebrew, none of which were widely known in Western Europe. Such translations as existed were very imperfect. Furthermore, medical knowledge, like all scientific and technological knowledge, cannot be effectively transmitted by words alone. Observation and didactic illustration are essential. Fortunately these needs were being met by the developments in humanism and art which culminated in the fifteenth century. The humanists having recovered the ancient Latin Literature then turned to recover the Greek. Competent Greek scholars were brought to Italy. The advance of the Ottoman Turks drove many more Greek scholars to Italy. These refugees brought their books with them. Bessarion alone accumulated a library of 900 works, mostly Greek, which he bequeathed to Venice. By the end of the fifteenth century hundreds of humanists had a fairly perfect knowledge of both Greek and Latin and knew how to edit copies of ancient manuscripts. Some of these humanists also possessed a knowledge of medicine, like Fracastorius, who alternated his lectures on medicine with lectures on classical literature, or Ermalao Borbaro, the scholarly Venetian noble who produced a complete edition and translation of Dioscorides, or Thomas Linacre, physician to King Henry VIII and a founder of the Royal College of Physicians who lectured on ancient literature and translated a number of the writings of Galen. Now for the first time all the writings of Galen were available to the West, and please remember that Fallopius, the most brilliant pupil of Vesalius at Padua, excused his teacher for having omitted a certain item of anatomy from his famous work because "the work of Galenus describing it had not yet been published."

While the humanists were perfecting their knowledge of ancient Greek as well as Latin, the artists were developing their techniques of drawing, and they defined these techniques so well that any student could master them. Leonardo da Vinci (died 1519) marks the culmination of that technical development. What this meant for the advance of the medical profession is best told in his own words:

> "And you who say that it is better to see the dissection than such drawings, you would speak well if it were possible to see all these things which are demonstrated in such drawings in a single specimen, in which you, with all your genius, will not see and will not obtain knowledge of for which I have dissected more than ten human bodies, destroying all other organs, consuming with very minutest particles all the flesh which surrounded these veins, without making them bloody except with insensible sanguinification of the capillary veins; and

one body did not suffice for so long a time, so that it was necessary to proceed by degrees with so many bodies that the complete knowledge might be fulfilled, which I twice repeated in order to see the difference.

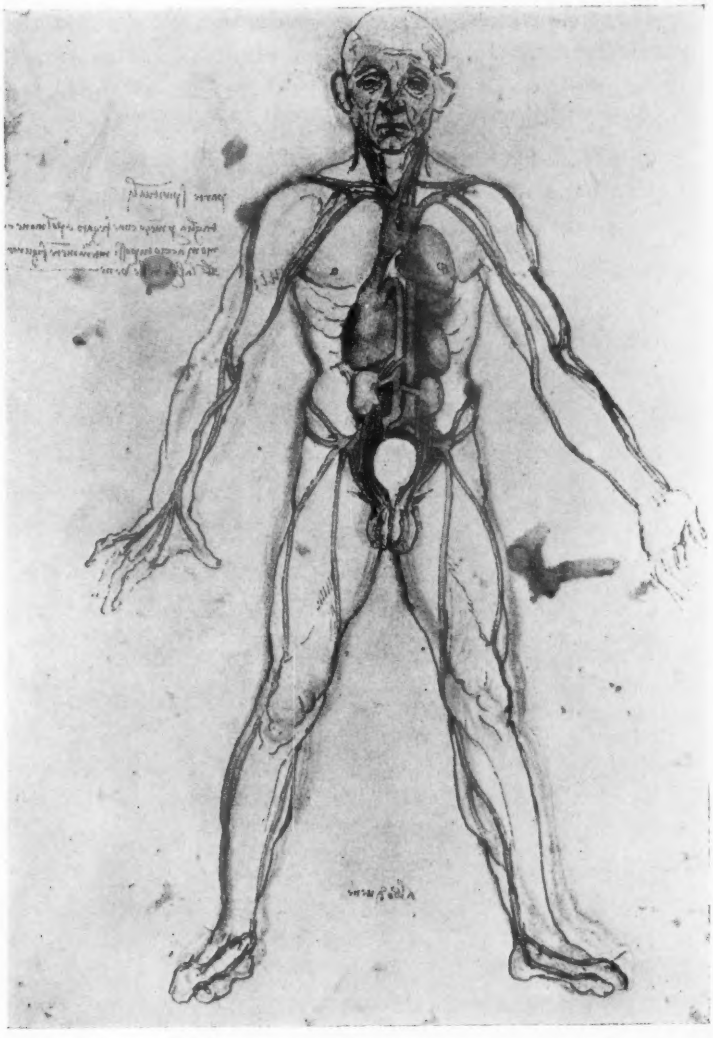


Fig. 4.—Illustration from the work of Leonardo da Vinci showing the circulatory system of the body. This shows the tremendous advance in anatomic understanding and presentation which had occurred between the twelfth and fifteenth centuries. (O'Malley, Charles D., and Saunders, J. B. de C.M.: Leonardo da Vinci on the Human Body, Henry Schuman, Inc., New York, 1952.)

"And if you do have love for such matters, you will perhaps be impeded by the stomach, and if that does not impede you, you will perhaps be impeded by the fear of living in the night hours in the company of such quartered and flayed corpses fearful to look at; and if this does not impede you, you will perhaps lack the good draughtsmanship which belongs to such demonstration; and if you have the draughtsmanship it will not be accompanied by the perspective; and if it is accompanied, you will lack the order of the geometrical demonstrations, and the order of the calculation of the forces and power of the muscles; and perhaps you will lack the patience, so that you will not be diligent.

"As to whether all these things have been in me or not, the hundred and twenty books composed by me will answer yes or no."[8]

Fortunately the possibilities of the recently invented printing press had become fully realized. The artists contributed the device of engraving their drawings on wooden or metal blocks so that writings on medical subjects, fully illustrated, could be published in editions of thousands, and scholarly publishers like Manutius in Venice and Froben in Basle saw to it that these works were correctly and well printed and bound. Little danger henceforth that important discoveries in medicine would be lost or that the medical profession would operate on a treadmill basis. There were now many universities, hundreds of teachers, and thousands of pupils, to seize eagerly upon every published new advance and add it to their libraries.

FRESQUE DE L'HOPITAL DE SIENNE, PAR TADDEO DI BARTHOLO.

Fig. 5.—A fresco of the hospital of Sienna, by Taddeo Di Bartholo, demonstrating the state of the hospitals of Italy at the time of Martin Luther's visit. (Charcot, J. M., and Richet, Paul: Les Difformes et les Malades dans l'Art, Lecrosnier and Babe, Paris, 1889.)

Let us stop to look at the best medical practice as it was at the end of the fifteenth century.

> "The hospitals of the Italians are built like palaces supplied with the best food and drink and tended by diligent servants and skillful physicians. The painted bed steads are covered with clean linen. When a patient is brought in, his clothes are taken off and given to a notary to keep honestly. Then they put a white bedgown on him and lay him between the clean sheets of the beautifully painted beds and two physicians are brought at once. Servants fetch food and drink in clean glass vessels, and do not touch the food even with a finger but offer it to the patient on a tray. Honorable matrons, veiled, serve the poor all day long without making their names known and at evening return home. These carefully tended hospitals I saw at Florence." [From a letter of Martin Luther.[9]]

And now let us observe the medical treatment in his last illness of the most glamourous figure of fifteenth century Italy, Lorenzo the Magnificent of Florence:

> "A few days yet passed before the end—hope for the moment was revived by the arrival of Ludovice il Moro's doctor, Lazaro, who prepared an elixir from pulverized pearls and jewels. The remedy was in full accord with the Platonic philosophy of the day, but it had as little efficacy as the heliotrope stone worn next to the skin which had been pressed on the sufferer as an infallible specific —Lorenzo's physician, Pier Leone, had never believed that Lorenzo would die. The Milanese doctor on his arrival declared that the previous treatment was mistaken, that whereas the patient needed refrigeratives, the remedies had been calorific. On his master's death, Pier Leone lost his reason."[10]

Thus shortly after the middle of the sixteenth century an educated medical profession in Western Europe had access to nearly all the accumulated medical and scientific literature that was available in the sixteenth century. Doubtless some of that earlier literature was lost. My knowledge of technical medicine is not such that I would feel warranted in any conclusion as to whether the contributions of the Arab-Jewish physicians, represented by such scholars as Avicenna, Maimonides, and Averroes, were sufficient to make up for what had been lost. I can assert, however, that Western Europe was again in full command of that ancient medicine as it had been passed down, that the medical profession had rejoined the full stream of knowledge and progress in its field, and in that sense it was fully reborn. But, as you have observed, it took Europe society a full 1,000 years of fumbling effort to recover the medical knowledge which it had so unwittingly abandoned in the sixth century.

If the actual gains of Western medicine over the ancient were not impressive, the promise for the future certainly was. There were now probably more medical schools than there had been in antiquity, and more students of medicine. Thanks to the printing press and to the contributions of the artists, it was now possible to transmit medical learning and any advance in it to thousands of interested students in permanent form. It was no longer necessary for each school or professor to do over what had already been done. All could move forward to the next stop. Furthermore the profession no longer was hidebound by tradition. It had discovered that even the ancient authorities might be wrong and thus developed a critical as well as experimental attitude. As Fallopius put it "Carpi in his revision of Mondino was the founder of modern anatomy and Vesalius had perfected it."[11] At first, after the appearance of the book of Vesalius, Fallopius thought there was nothing more to do in this field, but then he reflected that if Hippocrates, Galen, and all the other earlier authorities had erred, might not even Vesalius be in error, and so he resumed his study of anatomy with important results for medical knowledge. The same spirit led Fabricius to continue the study of anatomy and to become "the father of Embryology." It led William Harvey, pupil of Fabricius, to discover the circulation of the blood. Such was the spirit of the medical school at Padua throughout the sixteenth century.

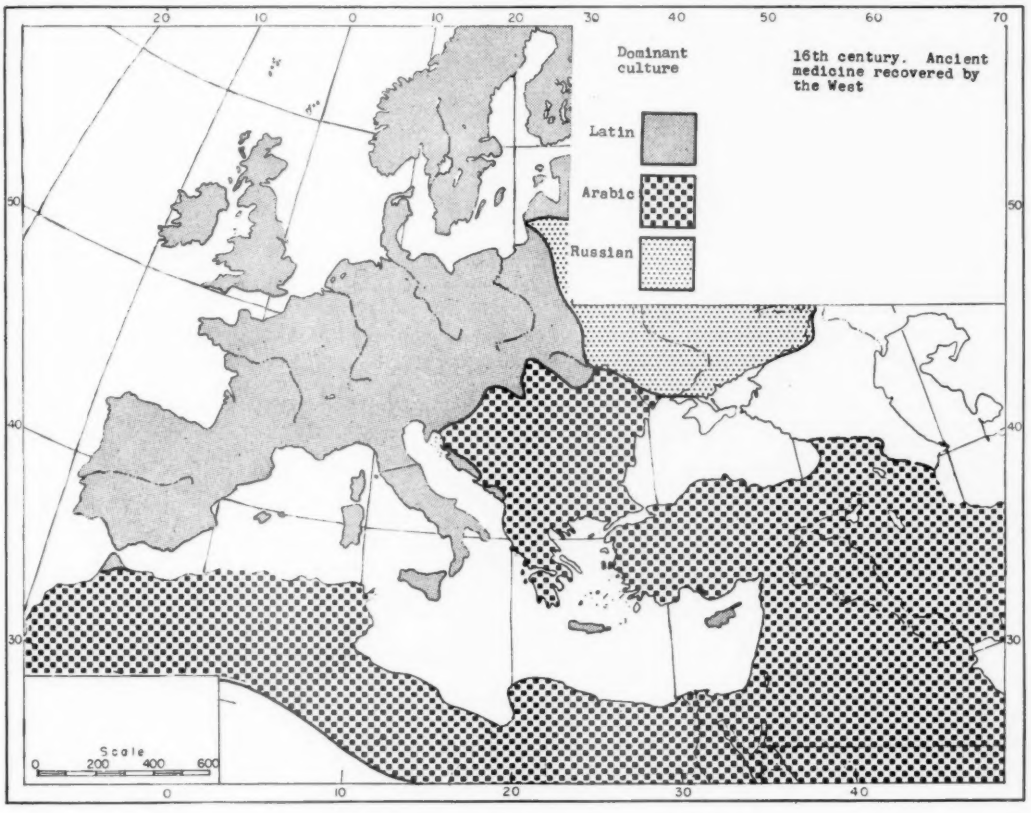
The inquiring spirit, so marked in the medical faculty at Padua and echoed at other centers, led its professors and students into many new areas. It was a doctor of medicine of Padua, Copernicus, who turned his attention to the stars and published his work on the movement of the heavenly bodies. It was another physician of Padua, Georgius Agricola, who wrote an equally epochal work on mining, metallurgy, and geology. Another, Jerome Cardan,

Fig. 62. *De Curtorum Chirurgia.*
Plate VIII

Fig. 6.—An illustration from the first book on plastic surgery by Gaspare Tagliacozzi (1545 to 1599) showing a pedicle flap from the forearm raised for rhinoplasty. This demonstrates the high degree of surgical skill and ingenuity which had been reached in Western Europe by the beginning of the seventeenth century. (Gnudi, Martha T., and Webster, Jerome P.: The Life and Times of Gaspare Tagliacozzi, Herbert Reichner, New York, 1950.)

made important contributions to mathematics. It was a professor of medicine at Padua, Galileo, who made important contributions not only to medicine but also to physics and astronomy. Paracelsus, who may have studied at nearby Ferrara, is treated with respect by students of chemistry and pharmacology if not always also by those of medicine and surgery, and Conrad

Gesner, another physician in Switzerland, became the first professor of biology, making important contributions to botany and zoology as well as to library sciences.



Map 5.

While in my professional capacity I figuratively patrol the 1,300 years up to A.D. 1600, personally I have not been altogether oblivious to the progress of the medical profession during the fifty years that I have been connected with universities in the twentieth century, and it is difficult to resist a comparison. The most marked change, of course, is the rapidity of transmission of advance in medical knowledge which was so painfully slow in the previous thousand years. Instead of the one manuscript known only to a half dozen persons, or the advance retained as a trade secret to be passed on orally and soon lost, there are now not only hundreds but thousands, perhaps even a hundred thousand, competent medical scholars all over the world not only eager to receive but just as eager to give to the profession the news of any advance. Such comparisons raise in my mind the question of whether there has not been more progress made in these last fifty years than in the untold millenia of previous development.

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Appraisal of Progress in Surgical Therapy

CONDUCTED BY WARREN H. COLE, M.D.
ASSISTED BY
J. GARROTT ALLEN, M.D. CLARENCE DENNIS, M.D.

SURGICAL TREATMENT OF CHRONIC RELAPSING PANCREATITIS

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FEW conditions have been treated by such a wide variety of surgical procedures as chronic relapsing pancreatitis. This fact itself attests the difficulties which have been experienced in the satisfactory surgical treatment of this disease. Our purpose in this paper is to review and correlate some of the present-day thoughts on this subject and to present the experience which our associates and we have had in the treatment of patients who have this refractory disease. Opinions and experiences have been reported by many authors; however, questions still await definitive answers.

CLASSIFICATION OF PANCREATITIS

The pathologic varieties, stages, and complications of pancreatitis make it advisable that any discussion of this subject should be conducted with as clear an understanding as possible of the exact type of pancreatitis under consideration. Certain definite forms of pancreatitis can be recognized clinically with considerable accuracy. However, variations and gradations of the disease, perhaps as it progresses from one form to another, make for mixed pictures and difficult specific clinical classification. We have used the following simple classification for several years. This classification is based on clinical experience and appears to have some practical value in establishing diagnosis as well as the indications for treatment.

1. Acute pancreatitis
    a. Acute edematous or interstitial pancreatitis
    b. Acute hemorrhagic or necrotic pancreatitis
2. Chronic relapsing pancreatitis
    a. Without complications
    b. With complications
3. Chronic pancreatitis
    a. Mild
    b. Advanced

The Mayo Foundation is a part of the Graduate School of the University of Minnesota.
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ACUTE AND MILD CHRONIC PANCREATITIS

Although we plan to limit the present remarks for the most part to chronic relapsing pancreatitis, brief comment on acute pancreatitis will be made in passing. For some years now it has been generally conceded that treatment of acute pancreatitis should be medical and should consist essentially of rest in bed, nothing by mouth, adequate sedation (preferably not with morphine), parenteral injection of insulin and calcium, if necessary, an indwelling duodenal tube, appropriate fluids given intravenously, methantheline bromide (Banthine) in regular doses, antibiotics, and perhaps repeated splanchnic blocks[21] with procaine hydrochloride. The milder of the acute forms of pancreatitis, that is, acute interstitial or edematous pancreatitis, will usually respond favorably in a brief period to such a regimen. Cortisone also has been suggested in the treatment of acute pancreatitis.[73]

During the last several years, however, there have been an increasing number of suggestions that surgical treatment should be considered and perhaps re-evaluated for the severe form of the disease, namely, for acute hemorrhagic pancreatitis or acute pancreatic necrosis.[34, 43, 53, 65, 71] Study of many opinions expressed in the literature indicates that current results of medical treatment are being compared with the results of surgical treatment of many years ago, at which time operative mortality in all conditions was much higher than it is today. Furthermore, these opinions seem to be based on results of the surgical treatment which was in use years ago, namely, wide incision and drainage of the pancreas, and not on the type of treatment currently suggested by some authors. It now is argued that if acute pancreatitis is caused by obstruction in the region of the ampulla of Vater, as secretion of the pancreas continues and reflux of bile into the pancreatic ducts perhaps occurs under increasing pressure, early decompression of the biliary tract may prevent rupture of the smaller radicles of the pancreatic ductal system with resultant extravasation of pancreatic juice into the pancreatic parenchyma and may thereby abort the process of acute pancreatic necrosis. At the same time, drains may be placed around the pancreas (without incision of the gland) to permit external drainage of irritant juices and exudates rather than to let them accumulate within the peritoneal cavity. This reasoning has some appeal and it appears to us that treatment of this type should be evaluated in selected cases.

One word about mild chronic pancreatitis. This term indicates slight induration in the head of the pancreas, in the absence of any symptoms referable to the pancreas. This mild form of pancreatitis is noted most often on palpation of the pancreas during operation for apparently uncomplicated cholelithiasis. In our experience such a finding rarely has clinical significance.

RELAPSING PANCREATITIS

Etiological Concept.—Current surgical treatment of relapsing pancreatitis is based largely on the etiological concept of the disease which was first advocated by Opie, Archibald, and Archibald and Mullally many years ago.

They suggested that acute changes within the pancreas resulted from obstruction produced by stone or spasm in the region of the ampulla of Vater; this obstruction presumably converted the bile duct and pancreatic duct into a continuous closed channel and permitted bile to enter the pancreatic ducts. Opie demonstrated in 1901 that bile injected into the pancreatic ducts of dogs caused acute hemorrhagic pancreatitis. Clinical evidence, however, supports the hypothesis that some obstruction must be present in order to have pancreatitis result from biliary reflux. For example, the main pancreatic duct may be visible in a cholangiogram. The logical assumption from this observation is that bile as well as radiopaque material has entered the pancreatic duct, yet the patient may show no evidence of pancreatitis.[15] Thus the majority opinion[24, 26, 30, 34, 50] now favors the etiological concept of reflux of bile into the pancreatic ducts due to a common passageway in association with some type of obstruction, either mechanical or functional (spasm of sphincter of Oddi), at the lower end of the common bile duct.

An excellent recent study on the anatomic relationships of the distal ends of the pancreatic and common bile ducts has been provided by Sterling. It has been stated[37] that the secretory pressures of bile and pancreatic juice are virtually identical and that the resistance which may be offered by the sphincter of Oddi is about three times as great as the secretory pressure of either one. Apparently many persons in whom pancreatitis does not develop[65, 74] have a common channel between the pancreatic and common bile ducts and, therefore, some obstructive factor seems essential to the development of pancreatitis.

It is also thought[55, 62] that an attack of acute pancreatitis may result from direct obstruction at the outlet of the pancreatic duct without regurgitation of bile. This leads to increased pressure in the ductal system of the pancreas and possibly to subsequent rupture of some of the smaller radicles and escape of pancreatic juice into the parenchyma of the gland. The exact mechanism may not be identical in every case as there may be more than one cause of obstruction.

Likewise, the amount of pancreatic stimulation may be a factor of importance since it is known that alcohol is a strong stimulant to the flow of pancreatic juice and the majority of patients who have relapsing pancreatitis are heavy imbibers of alcohol. On the other hand, the majority of chronic alcoholics do not have pancreatitis so that excessive stimulation of the pancreas by itself appears to be an insufficient cause of pancreatitis in most patients. This again suggests some additional factors such as obstruction. The importance of an accurate understanding of etiology is obvious if treatment is to be directed intelligently. Doubilet and Mulholland,[30] who have been careful students of this problem and who have had a large clinical experience, have stated that spasm of the sphincter of Oddi provides the obstructive factor in most patients.

It seems unlikely that trauma, vascular abnormalities, or virus infection, which have been considered the cause of acute pancreatitis in a limited number of cases,[44] are often the cause of relapsing pancreatitis.

Surgical Treatment.—Surgical procedures which have been employed in the treatment of relapsing pancreatitis include among others cholecystostomy, cholecystogastrostomy or cholecystojejunostomy, cholecystectomy, choledochostomy, choledochoduodenostomy or choledochojejunostomy, partial gastrectomy, sympathectomy, vagotomy, internal or transduodenal sphincterotomy, partial resection of the pancreas, and total pancreatectomy. A list of this length in itself indicates the difficulty which has been experienced in the surgical treatment of this disease and the thinking and effort which these difficulties have engendered. In general, the various forms of treatment which have been employed, in addition to correction of primary disease in the biliary tract, may be grouped as follows: (1) direct drainage of biliary tract, either external or internal; (2) procedures to decrease stimulation of pancreatic secretion; (3) procedures to relieve spasm or other types of obstruction in the region of the sphincter of Oddi or terminal portion of the main pancreatic duct; (4) direct operation on the pancreas; and (5) various operations on the nervous system used primarily for relief of pain.

These general categories of treatment will be considered individually. It goes without saying that disease within the biliary tract should be corrected at the time of any operation for relapsing pancreatitis not only to correct any abnormality in the biliary tract itself but also because of the etiological role which biliary calculi may have in the production of pancreatitis. This may necessitate cholecystectomy for cholelithiasis or removal of stones from the common bile duct. In some cases, if there have been stones in the common bile duct, these measures alone may be followed by favorable results with regard to the pancreatitis, but this is by no means always true. A question arises whether the gall bladder should be removed if it presents a normal appearance. Little comment relative to this point is found in the literature, but from discussion with various surgeons it appears that it is common practice not to remove the gall bladder under these circumstances. In contrast, however, routine cholecystectomy has been recommended at the time when sphincterotomy is performed whether or not the gall bladder is diseased.[30, 46] The objective evidence in support of this practice is not known to us although theoretical considerations, such as the possibility of decreasing biliary pressure in the common duct, might favor such practice. It is, of course, well known that cholecystectomy by itself will not prevent recurring attacks of pancreatitis.

External Drainage of Biliary Tract.—External biliary drainage, accomplished by cholecystostomy, was one of the earliest procedures suggested[4] for chronic relapsing pancreatitis. This procedure is not recommended today. On the other hand, prolonged drainage of the common bile duct by use of a T tube has been employed by many surgeons and probably has been used more often than any other single procedure[13, 14, 45, 59, 77, 78]; however, not many reports of long-range results after this procedure have appeared in the literature. It is, of course, difficult to understand just how such a procedure can produce lasting changes (after removal of the T tube) which might prevent recurrence of the disease. Perhaps prolonged decompression of the biliary tract

permits satisfactory subsidence of acute changes in the pancreas and associated structures which in turn relieves the obstructive factors in the ampullary region. This operation lacks the appeal of some direct effort toward permanent improvement in drainage. A number of patients, however, have been relieved after simple choledochostomy, especially when associated with removal of stones from the common bile duct. Our own experience with external biliary drainage will be discussed later.

Surgeons experienced in the treatment of pancreatitis probably use simple drainage of the common duct with a T tube less often than in former years. On the other hand, it may prove to be a useful procedure for the surgeon who only occasionally and unexpectedly encounters definite evidence of pancreatitis at the time of operation or when other procedures present unusual hazards or technical difficulties.

Internal Drainage of Biliary Tract.—Some form of internal biliary drainage has been employed with considerable frequency.[33, 47] In past years the gall bladder was frequently joined by a side-to-side anastomosis to the stomach or jejunum to accomplish this purpose, but this procedure is probably not used as frequently today although we know of a few patients who had definite relapsing pancreatitis who have been completely relieved for many years after such an operation. A Roux-Y type of anastomosis between the gall bladder and jejunum has been employed more recently for this purpose.[55] Some surgeons establish a simple side-to-side choledochoduodenostomy to accomplish this purpose.[59] The main objections raised to this procedure are two in type, namely, that reflux cholangitis may occur and that the stoma may not remain patent. In our opinion reflux cholangitis is rarely a matter of significant clinical concern so long as obstruction does not develop. Some surgeons do not agree with this opinion. In some cases the stoma may not remain open indefinitely unless there is obstruction at the lower end of the common duct. Actually, it is often difficult to be certain whether or not the stoma has remained patent. It seems possible that if a small elliptical-shaped portion is excised from the common duct in making the anastomosis, the stoma is more likely to remain patent than if a simple incision is made in the duct. We have utilized this procedure in a few cases.

Some form of anastomosis between the common duct and jejunum in which a defunctionalized loop of intestine is used for the anastomosis has been recommended by various authors, including Bowers, Bowers and Greenfield, Peterson and Cole, and others.[5, 13, 55] Some surgeons have severed the common duct and made an end-to-end choledochojejunostomy between the upper end of the common duct and the end of a defunctionalized loop of jejunum. The possibility that duodenal ulcer will develop is always a potential hazard after this type of operation. Deliberately cutting across a normal common duct except for the removal of a malignant lesion is probably an act which an ordinary surgeon finds repulsive except under extreme circumstances. We have found no reports of five-year follow-up after biliary-intestinal anastomosis with use of a defunctionalized loop of small intestine, but favorable early results have

been reported in relatively small series of cases. Our own results with internal biliary drainage are reported later in this paper.

Procedures to Decrease Pancreatic Secretion.—As stimulation of pancreatic secretion has been considered an aggravating factor in pancreatitis, surgical as well as medical measures to decrease pancreatic secretion have been employed in the treatment of this disease. One patient observed by Richman and Colp[66] was relieved of recurring pancreatitis, to the time of their report, ten months after partial gastrectomy for gastric ulcer. Subsequently, these authors reported three other cases in which similar treatment[67] was employed with two good results, the longest interval since operation being twenty-two months. Johnson[39] reported one case in which partial gastrectomy had given no relief. Actually this operation has been used infrequently and we would not consider it a procedure of choice in the treatment of chronic relapsing pancreatitis unless its use was necessary in the management of some complication of the disease or it was employed as an associated procedure to partial or total pancreatectomy.

Vagotomy has been employed, usually in association with some other procedure, with the thought that this would decrease the secretion from the pancreas. Rienhoff and Baker reported a case in 1947 in which bilateral transthoracic vagotomy and sympathectomy were performed with relief for the one year that the patient was followed. Actually experimental evidence of any striking effect of vagotomy on pancreatic secretion is somewhat conflicting.[69, 76] On the other hand, some authors have reported favorable results in experimental pancreatitis[70] as well as for patients[50] from use of vagotomy. Failure of this procedure to provide relief has been reported by others.[61] We would not recommend vagotomy alone as definitive treatment of chronic relapsing pancreatitis. Whether it might be used to advantage in association with certain other procedures has not as yet been satisfactorily answered. It also had been suggested that vagal activity may be responsible for spasm of the sphincter of Oddi but we have not found objective evidence which supports this concept. Banthine is used in the medical treatment of acute episodes of pancreatitis and also in treatment of some small pancreatic fistulas.

Sphincterotomy.—Many of the recent reports in the literature on the treatment of chronic relapsing pancreatitis relate experiences with the use of sphincterotomy. The impetus for this type of treatment is largely due to Doubilet and Mulholland,[23-27, 29, 30] who with their associates have written extensively on this subject. Spasm of the sphincter of Oddi was suggested as a possible cause of pancreatitis by Archibald and Mullally in 1913, but this possibility did not receive widespread attention until more recent years. Many surgeons who have used this treatment in recent years have not reported their experience as yet although some reports have appeared.[31, 46] Originally Doubilet and Mulholland employed for endoductal sphincterotomy an instrument which was passed down the common duct and served as a sphincterotome; this procedure was reported by Colp, Doubilet, and Gerber experimentally in 1936. Doubilet and Mulholland now more often employ transduodenal sphincterotomy with the aid of a special catheter.[22] For the most

part we have used an old-fashioned grooved director for the same purpose and find that this stretches the region of the sphincter across the groove in the director so that it can be readily incised. Sphincterotomy can be accomplished by other methods, of course. Jones and Smith described a method in which a portion of the sphincter is grasped between small curved forceps and excised.

Since 1946 Mulholland, Doubilet, and their associates have performed either endoductal or transduodenal sphincterotomy on 190 patients.[52] There were nine operative deaths. There have been seven definite recurrences, all of which occurred in cases of severe alcoholism; the patients remained well during abstinence from alcohol. One patient died eight months after operation from carcinoma of the pancreas which the authors stated was undoubtedly present but not recognized at the time when sphincterotomy was performed. It is thought that the course of the disease was definitely reversed in the remaining 173 patients. The period of observation following operation has been relatively short for a number of these patients. Jones reported that he has performed his type of sphincteroplasty without mortality on fifteen patients who had definite chronic relapsing pancreatitis. The average length of follow-up on these patients was seventeen months at the time of his report. Only two of the fifteen patients had recurrences.

These results have been so encouraging that at present this procedure is probably one of the most frequently employed by surgeons over the country. Although it is perhaps too early for an accurate definitive evaluation of this operation, the encouraging results with its use to date and the lack of a high percentage of good results from other procedures of similar magnitude make it a reasonable operation to employ in treatment of many patients who have chronic relapsing pancreatitis. Details of technique vary considerably in operations on the sphincter of Oddi as reported by different surgeons. More time will be needed to determine the simplest, safest, and most effective of these procedures.

Doubilet and Mulholland[28] suggested that sphincterotomy should be employed even in the presence of advanced chronic pancreatitis with calcification, and they have reported four such cases. They stated that all four of the patients were relieved. Three of them were followed for two years and one for five months. It is the opinion of these authors that the presence of calcification does not alter the pattern of pain, the progressive digestive symptoms, or eventual outlook and, likewise, that it does not alter the course of the disease or the indications for treatment. It is generally agreed that calcification in the pancreatic parenchyma may result from repeated episodes of acute or subacute pancreatitis and that its presence does not offer evidence of any different type of process. Occasionally a patient is encountered who has extensive pancreatic calcification but has never experienced pain; this condition is a little difficult to explain. At least under these circumstances the exact mechanism of its production seems to be different from that in most patients although it always appears to be associated with extensive chronic inflammatory changes. Doubilet and Mulholland also have observed the gradual

disappearance of a pancreatic cyst subsequent to sphincterotomy.[52] Most surgeons prefer some direct operation on the cyst, such as external or internal drainage or possibly, in the exceptional case, excision.

Direct Operation on Pancreas.—During recent years direct operation on the pancreas has been performed more frequently than in former years for chronic relapsing pancreatitis and the complications which may be associated with this disease. At times calculi will be found in the pancreatic ducts, in association with pancreatitis, either with or without extensive calcification in the pancreatic parenchyma. Under these circumstances it is necessary to remove the calculi from the ducts in order to relieve obstruction to drainage of pancreatic juice. This may be done by incision of the pancreatic duct and removal of stones much as they are removed from the common duct (Fig. 1). A T tube may be left in the pancreatic duct temporarily. It has been our experience that if all calculi are removed and no obstruction remains, drainage will cease when the T tube is removed as promptly as when a similar tube is removed from the common bile duct. Removal of pancreatic calculi has been reported by other authors.[32, 49]

Pseudocysts of the pancreas are found associated with chronic relapsing pancreatitis with relative frequency. Most surgeons advocate some type of drainage operation for such cysts. In past years these have been treated most often by marsupialization and prolonged external drainage.[9, 38, 42, 57] This is a relatively safe and simple type of procedure and is followed by good results in most patients if drainage is maintained for an adequate period. This may mean three to twelve months or even longer. Occasionally such a drainage tract fails to close, in which event it may be anastomosed to the stomach[19] or some other appropriate part of the gastrointestinal tract if it has become well epithelialized. It is, of course, not pleasant for the patient to have prolonged external drainage of pancreatic juice. Partly because of this fact, internal drainage of pancreatic cysts has been employed more frequently during recent years.[1, 12, 51, 58, 60] A pseudocyst of the pancreas may present in one of a variety of locations and, depending on its proximity to various parts of the gastrointestinal tract, it may be anastomosed directly to the stomach (Fig. 2) or duodenum. If the pseudocyst is anastomosed to the jejunum, a Roux-Y type of anastomosis has been recommended.

Although experience with internal drainage of pancreatic cysts is still rather limited and not many late results have been reported, it is gaining in favor and its use will undoubtedly increase. Puestow has reported one of the largest experiences in this field.

For the most part, resection of the pancreas has been performed rather infrequently for chronic relapsing pancreatitis and usually only after less radical procedures have failed to give relief. Occasionally even at an initial operation, however, marked involvement of the head of the pancreas will be noted, perhaps in association with numerous calculi in the ducts and calcification of the pancreatic parenchyma. If the remainder of the gland is relatively uninvolved, the best result may be obtained under these circumstances

with resection of the head of the pancreas. Obviously this is not an operation which is undertaken lightly especially for benign disease and, as mentioned previously, it is ordinarily advised only after less radical procedures have failed. Results of partial pancreatectomy for chronic pancreatitis have been reported by Cattell and Warren,[11] Rhodes, Howard, and Moss, Rienhoff and

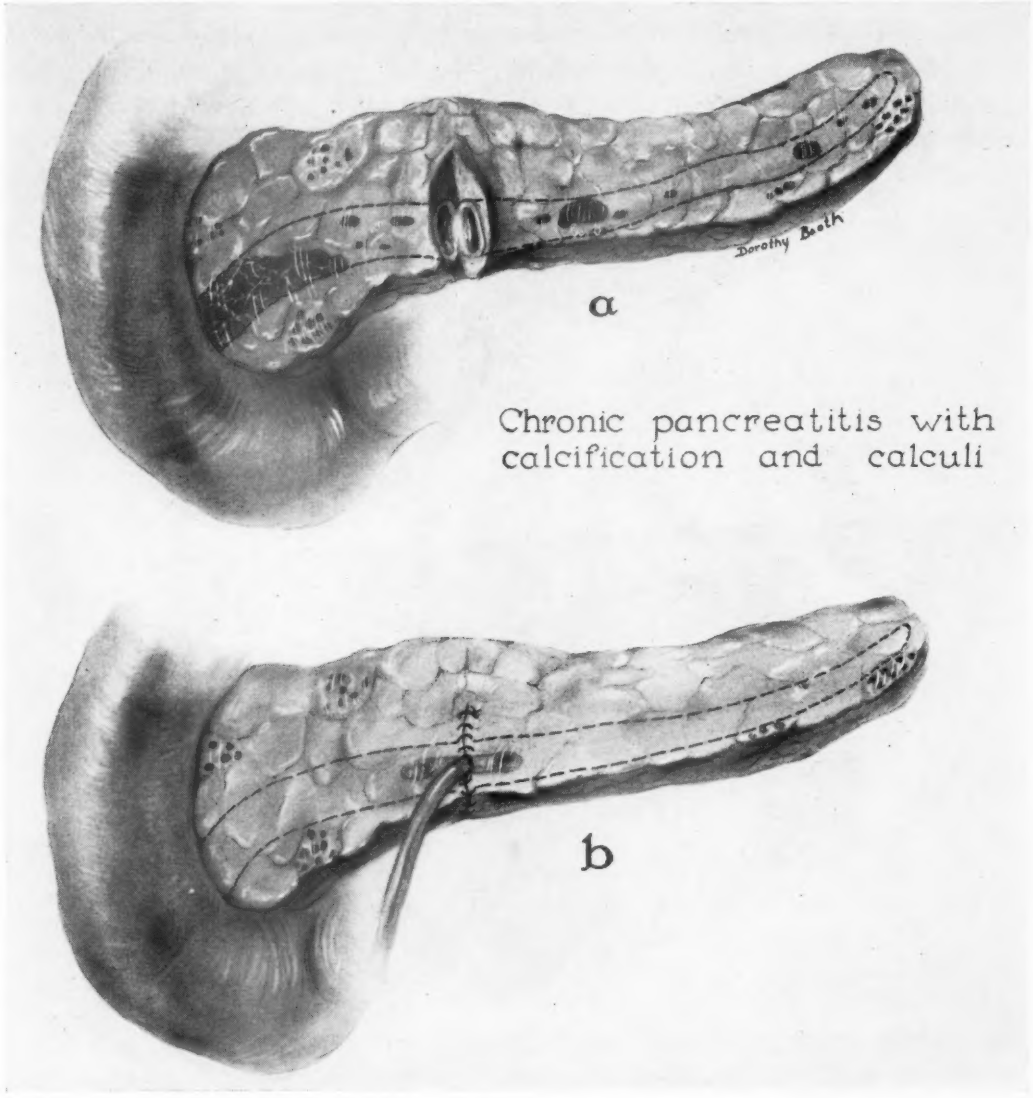

Fig. 1.—*a* and *b*, Removal of stones from pancreatic duct.

Baker, Waugh,[78] and Whipple. Although the operative mortality and morbidity from partial pancreatectomy are obviously greater than for less extensive procedures, the results after this operation appear to justify the hazards if nothing of a less formidable nature will afford relief. This operation should, of course, be performed so that pancreatic juice from the remainder of the gland drains into the intestinal tract, along with the bile, proximal to the

gastrojejunal anastomosis. Resection of the tail and perhaps part of the body of the pancreas, so-called distal pancreatectomy, has been employed in some cases,[10, 47] but in an insufficient number to permit evaluation of results.

Total pancreatectomy for chronic pancreatitis has been reported by Waugh and co-workers,[79, 80] Rhodes, Howard, and Moss, and Whipple and perhaps others. This extensive operation has been used for only a limited number of patients and should be employed only in the exceptional case, in which various other less radical operations have failed. It may occasionally be considered for the patient who is utterly miserable when no other opportunity for relief appears available.

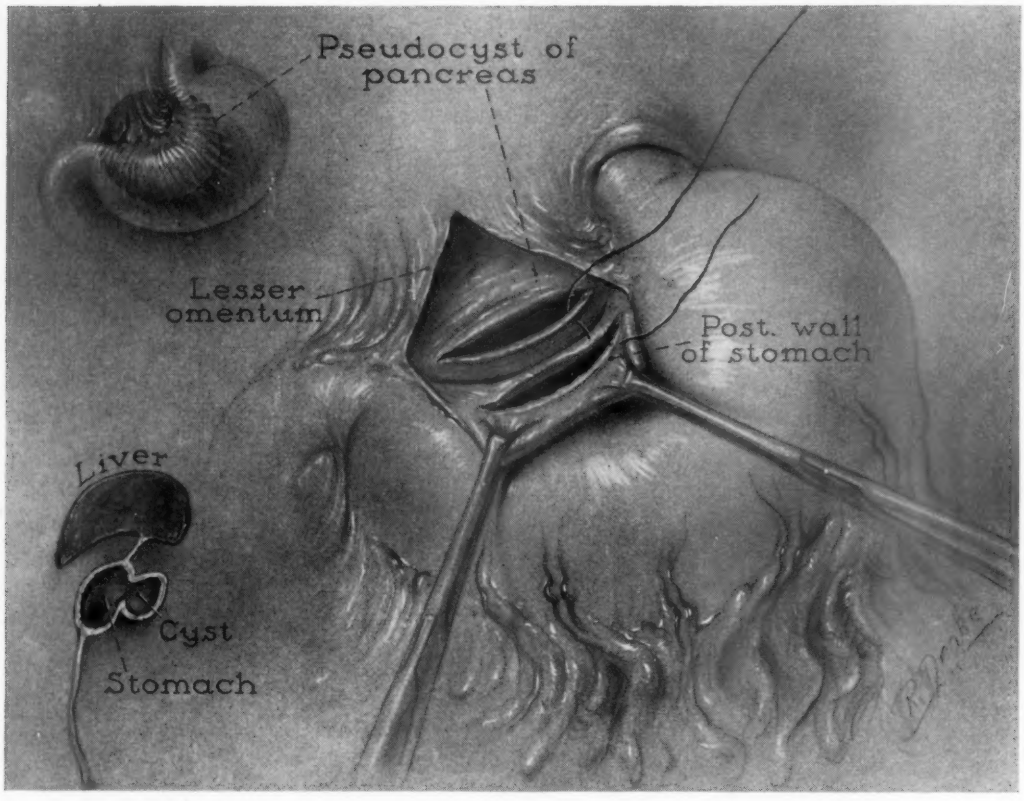

Fig. 2.—Internal drainage of pseudocyst of the pancreas by anastomosis to posterior wall of the stomach.

Operations Primarily for Relief of Pain.—Many reports have appeared in the literature in recent years on the use of various types of sympathectomy for relief of pain caused by pancreatitis. In our opinion, procedures of this type should be employed only after corrective types of operation have failed or if the pancreas has been virtually completely destroyed, advanced chronic pancreatitis is present, and the patient has constant pain. This type of operation, of course, does nothing to prevent further damage to the pancreas or to eliminate the cause of the disease.

Mallet-Guy and de Beaujeu have been interested in the treatment of pancreatitis by sympathectomy for some years and reported on a series of seventy patients in 1950. Eighty-three per cent showed remarkable improvement after the operation. Only thirty-seven of these patients, however, were followed for more than one year. Interest in this procedure in this country was stimulated considerably by the reports of Smithwick in 1946 and Rienhoff and Baker in 1947, each of whom reported on one patient who had been free of pain for one year after bilateral vagotomy and sympathectomy when the report was made. Since that time many other reports have appeared in the literature.[20, 35, 36, 61, 65, 72, 75] For the most part these reports deal with small numbers of patients who have had favorable results but who have been followed for only a relatively short period. We have not found in the literature reports of studies made five years after sympathectomy for pancreatic pain even by those who reported early results that were favorable. Ray and his associates have made some of the most extensive studies of pathways of pancreatic sensation and have observed that stimulation of the head of the pancreas may cause pain in the left side of the abdomen after sympathectomy on the right side. This, of course, indicates the necessity of bilateral operation if relief is to be expected, although good results for short follow-up periods were noted from the unilateral operation by some authors in earlier reports. Ray also demonstrated that the vagus nerves carry no sensory fibers from the pancreas. He found that pain sense from the pancreas goes by visceral afferent nerves that traverse the celiac plexus, splanchnic nerves, and sympathetic chains on both sides. He found that the principal pathway is by way of the greater splanchnic nerves.

There appears to be no complete uniformity of opinion regarding the extent of the sympathectomy which is advisable. Some surgeons perform only bilateral resection of the splanchnic nerves, whereas others have included the twelfth thoracic and first lumbar nerves as well as even more extensive operations.[35, 36, 61] Ray and Console are among the latter, although they have suggested that bilateral resection of the splanchnic nerves may be sufficient.

Patients whom we have seen who have had at least bilateral splanchnicectomy or perhaps a more extensive type of sympathectomy performed by our neurosurgical colleagues for advanced chronic pancreatitis have not done well as a group. A few patients have been temporarily relieved for perhaps one or two years, and some additional patients have been partially relieved for longer periods. We know of no patient, however, who has been completely relieved for five years. It is difficult to understand why a patient may be temporarily relieved by an operation of this type and then have recurrence of pain apparently originating in the pancreas. The same type of recurrence has been noted after a variable period of freedom when this operation is performed for relief of pain caused by cancer of the pancreas. The usual explanation given under these circumstances is that the disease has progressed beyond the pancreas. Perhaps this is the explanation in cases of chronic pancreatitis but this explanation seems open to question.

REVIEW OF PRESENT SERIES OF CASES

Criteria for Evaluation of Results.—In order to evaluate the experience which our associates and we have had in the treatment of relapsing pancreatitis, the records of 100 patients treated surgically at the Mayo Clinic for chronic relapsing pancreatitis between the years 1932 and 1949 have been reviewed. The records of many more patients were surveyed but only those were included which gave definite and clean-cut evidence of the disease according to the criteria reported by Comfort and his associates.[17, 18] Likewise, patients on whom satisfactory follow-up information could not be obtained were not included. Whenever there was any doubt as to the existence of carcinoma the case was excluded from study. Carcinoma of the pancreas was not known to have developed during the ensuing years in any of the patients who had chronic relapsing pancreatitis at the time of operation.

All the patients in the present study were followed for more than three years after operation. Approximately one-third of the patients were followed for three to five years, but all the remainder were followed from five to nineteen years. Follow-up information was obtained for the most part by reexamination of the patient, but in some instances it was obtained from the family physician or the patient himself.

When the results of treatment of chronic relapsing pancreatitis are being evaluated, the two main considerations appear to be the abdominal pain and deterioration in pancreatic function. The former is the most obvious and most distressing symptom to the patient and reflects fairly well the activity of the disease. Although some tests of external pancreatic function are perhaps fairly reliable and the development of diabetes can, of course, be detected, these features of the disease do not serve as well as abdominal pain for evaluation of a given operative result.

Therefore, we have attempted to evaluate surgical therapy on the basis of the relief of the abdominal pain. Patients were considered completely relieved if the patient stated that he had been completely relieved of abdominal pain and had required no medication or other treatment for abdominal distress. Patients considered partially relieved were definitely improved after operation but not completely relieved. Those who had no relief are so classified. Almost all of the last group were subjected to further surgical procedures. Many patients had multiple operations both before and after the particular operation considered in the present report.

Patients who have chronic relapsing pancreatitis present many variables when one attempts to evaluate surgical results. These include, among other things, the presence or absence of disease in the biliary tract, the significance of perhaps one or more previous operations, the degree of advancement of the pathologic process in the pancreas and the presence or absence of such associated changes as calcification in the pancreatic parenchyma, stones in the pancreatic ducts, formation of a pseudocyst, and internal or external pancreatic insufficiency. In addition, the type of operation which has been performed must naturally be considered. If a follow-up study is broken down into small

groups to determine results according to these categories, one is left with such a small number of patients in any given group that the interpretation of results is questionable. On the other hand, if some effort of this type is not made, it is impossible to evaluate the importance of these associated findings.

One observation appears certain, namely, that because of the nature of the disease and its tendency to recurrence, any study which does not encompass a follow-up of at least five years is of questionable value. Actually, we encountered one patient who was completely free of symptoms five years after operation and then experienced recurrence. The same was true of another patient after twelve years of complete relief. Of course it is possible that symptoms recurred because of spontaneous closure of the biliary intestinal stoma previously established in these patients.

Our experience and that of our associates in the treatment of chronic relapsing pancreatitis has been in past years primarily with external and internal biliary drainage, and follow-up studies for a significant period have been made on patients who had these types of operation performed. During the last few years we have employed transduodenal sphincterotomy in an increasing number of patients but as yet the period of follow-up study of these patients is not adequate to permit evaluation of this form of treatment.

External Biliary Drainage.—Follow-up data were obtained on seventy-two patients who had external biliary drainage established (Table I). Of the entire group, 52 per cent were completely relieved and 22 per cent were partially relieved. A somewhat higher percentage of patients (62 per cent) were completely relieved if biliary tract disease was present (stones, in almost every case) than if there was no disease in the biliary tract (40 per cent). The groups of cases are small but the findings do suggest that a somewhat larger percentage of patients is completely relieved by this procedure if there is associated disease in the biliary tract than if this is not the case. On the other hand, the total percentage of patients partially or completely relieved was rather similar in both groups (77 per cent if biliary disease was present and 70 per cent if no biliary disease was present).

TABLE I. RESULTS OF EXTERNAL BILIARY DRAINAGE IN PRESENCE OR ABSENCE OF DISEASE IN BILIARY TRACT

DISEASE IN BILIARY TRACT	PATIENTS	COMPLETE RELIEF		PARTIAL RELIEF		NO RELIEF	
		NUMBER	PER CENT	NUMBER	PER CENT	NUMBER	PER CENT
Absent	33	13	40	10	30	10	30
Present	39	24	62	6	15	9	23
Total	72	37	52	16	22	19	26

One question which always arises when external biliary drainage is employed is how long the T tube should be left in place. We used to think that the T tube should remain in place at least six to twelve months. Reference to Table II indicates, however, that actually more patients have been completely relieved after this operation when the T tube has been left in place six months or less than when it has been permitted to remain more than six months.

TABLE II. RESULTS OF EXTERNAL BILIARY DRAINAGE ACCORDING TO DURATION OF DRAINAGE*

DURATION (MO.)	PATIENTS	COMPLETE RELIEF		PARTIAL RELIEF		NO RELIEF	
		NUMBER	PER CENT	NUMBER	PER CENT	NUMBER	PER CENT
Less than 3	22	12	54	5	23	5	23
3 to 6	18	11	61	2	11	5	28
More than 6	32	14	44	9	28	9	28
Total	72	37	52	16	22	19	26

*All patients, including those with and without disease in biliary tract.

It is difficult, of course, to tell how many of the favorable results were due to the external drainage and how many to removal of biliary calculi in the group in which biliary calculi were found at the time of operation.

Internal Biliary Drainage.—Results obtained after internal drainage are shown in Table III. In most cases this operation consisted of a side-to-side choledochoduodenostomy. In a few cases the gall bladder was anastomosed to the intestinal tract. A defunctionalized loop of jejunum was used only rarely. Again the groups of cases are small, but if any suggestions are drawn it appears that somewhat superior results may be expected after this operation if there is associated disease in the biliary tract than if this is not the case.

TABLE III. RESULTS OF INTERNAL BILIARY DRAINAGE ACCORDING TO PRESENCE OR ABSENCE OF DISEASE IN BILIARY TRACT

DISEASE IN BILIARY TRACT	PATIENTS	COMPLETE RELIEF		PARTIAL RELIEF		NO RELIEF	
		NUMBER	PER CENT	NUMBER	PER CENT	NUMBER	PER CENT
Absent	16	5	31	7	44	4	25
Present	12	6	50	4	33	2	17
Total	28	11	39	11	39	6	22

When the results after internal drainage are compared with those after external drainage, it should be mentioned that for the most part the former operation was employed for the more advanced type of disease and often after other procedures had been tried and failed or only afforded temporary or partial relief. Thus it is noted from Tables II and III that external drainage was followed by complete relief of symptoms in a somewhat higher percentage of cases than internal drainage, but on the other hand if one considers patients who had either complete or partial relief, the results were slightly more favorable after internal than external drainage. These differences are not great, however, and it is doubtful if they are significant.

Disease of the Biliary Tract.—As has been pointed out by Comfort and his associates,[17, 18] approximately one-half the patients who have relapsing pancreatitis have associated disease (stones, in most cases) in the biliary tract. This incidence of simultaneous occurrence of these two conditions is obviously higher than one would expect were there not some relationship between these diseases. It, therefore, seemed of interest to determine if the presence or absence of disease in the biliary tract influenced results obtained after the use of internal or external biliary drainage. The disease in the biliary tract was

corrected at the time of operation in all patients who had it. Reference to Table IV indicates that better results were obtained when there was associated disease in the biliary tract than when this was not the case.

TABLE IV. INFLUENCE OF DISEASE IN BILIARY TRACT ON RESULTS OF BILIARY DRAINAGE (BOTH INTERNAL AND EXTERNAL)

DISEASE IN BILIARY TRACT	PATIENTS	COMPLETE RELIEF		PARTIAL RELIEF		NO RELIEF	
		NUMBER	PER CENT	NUMBER	PER CENT	NUMBER	PER CENT
Absent	49	18	37	17	35	14	28
Present	51	30	59	10	20	11	21
Total	100	48	48	27	27	25	25

Complications.—The question naturally arises whether the presence of certain complications of relapsing pancreatitis might alter results of the surgical procedures, such as internal or external biliary drainage. In an effort to answer this question, all patients in the present series were divided into two main groups, namely, those with and those without complications. Those in the so-called complicated group evidenced one or more of the following conditions: diabetes, persistent steatorrhea, pancreatic calcification, or cysts. In some patients in this group more than one surgical procedure was carried out at a given operation. Results of the comparison are shown in Table V. Thus, it is seen that better results may be expected if surgical treatment is instituted before complications or advanced changes have occurred in the pancreatic parenchyma.

TABLE V. RESULTS OF INTERNAL AND EXTERNAL BILIARY DRAINAGE WITH AND WITHOUT COMPLICATIONS*

COMPLICATIONS	PATIENTS	COMPLETE RELIEF		PARTIAL RELIEF		NO RELIEF	
		NUMBER	PER CENT	NUMBER	PER CENT	NUMBER	PER CENT
Absent	63	34	54	16	25	13	21
Present	37	14	38	12	32	11	30
Total	100	48	48	28	28	24	24

*Include at least two of the following: diabetes, steatorrhea, calcification, or cyst.

Other Procedures.—Our experience with the use of other surgical procedures will not be reported in detail at this time; however, a few comments might be made. We have had no significant experience with procedures designed to decrease pancreatic secretion. Vagotomy has not been employed as definitive treatment. The same is true of gastric resection, although this has been used occasionally in the treatment of certain complications of pancreatitis.

We have employed transduodenal sphincterotomy in an increasing number of cases during recent years. At this time, however, we do not have any five-year follow-up studies to report. It can be said that early results after this operation have been encouraging. In a group of fifteen patients in whom this operation was performed nine months to three years previously, there were only two patients who appeared to have no benefit from the procedure. Seven patients have been completely relieved of recurrent attacks of pain and five have been partially but not completely relieved. Sphincterotomy has been

employed in additional patients in whom follow-up studies have not been made as yet or in whom other surgical procedures were performed simultaneously, making it impossible to ascertain the effect of sphincterotomy alone. Obviously this experience is too limited to permit conclusions but we have been sufficiently encouraged to continue its use in an increasing number of patients.

Direct operations on the pancreas have been employed in a relatively small number of patients. In some, stones have been removed from the pancreatic ducts with uniform relief of symptoms. In others, the head of the pancreas has been resected. This has afforded relief in virtually all cases in which it has been employed. It has not been used, as a rule, unless other less extensive operations have failed to give relief. Resection to include the tail and perhaps the body of the pancreas has been performed in occasional selected cases. It is, of course, not a procedure to be used routinely but may be helpful in certain unusual types of cases in which the inflammatory changes are largely limited to this portion of the pancreas. Total pancreatectomy has been employed by our associates[80] in several cases. Surgical treatment of pseudocysts of the pancreas will not be discussed at this time.

Operations designed primarily for the relief of pain have been employed in some patients with advanced chronic pancreatitis. Twelve patients who had bilateral splanchnicectomy performed by our neurosurgical colleagues were included in the present study. None of these have remained free of pain over a period of years. A number of them were completely relieved for a matter of months and then pain returned. Seven of the group had partial relief of pain.

COMMENT

It is obvious that at present there are many differences of opinion regarding the etiology, pathologic physiology, and treatment of relapsing pancreatitis. It appears likely that the disease may be produced by more than one mechanism and the mechanism responsible may depend on the anatomic relationships at the terminal portions of the common bile and pancreatic ducts. Thus, in some patients with a certain anatomic relationship, a stone in the ampullary region may be mainly responsible for recurring attacks of pancreatitis. The frequent finding of biliary calculi in patients who have relapsing pancreatitis seems to suggest such a relationship. Likewise, some patients have no further attacks of pancreatitis after removal of all biliary calculi. Other patients with pancreatitis have no biliary calculi and the disease may be caused by obstruction of the terminal portion of the pancreatic duct directly or indirectly by obstruction in the sphincter of Oddi.

Experience of recent years indicates that rendering the sphincter of Oddi incompetent by some type of transduodenal operation may offer a good chance of relief from recurring attacks. The most impressive results found in the literature are those reported by Doubilet and Mulholland after this type of operation. Such an operation might well relieve obstruction in the terminal portion of the pancreatic duct when an anastomosis between the choledochus and the intestinal tract might fail to do so if the termination of the pancreatic

duct has been obstructed by contracture (spasm or cicatricial) of the sphincter of Oddi. It also appears likely that the exact type of surgical procedure performed in accomplishing "sphincterotomy" may significantly affect the results obtained. Thus, the length of the incision in the region of the sphincter, whether or not sutures are placed to unite the ampulla of Vater with the duodenum, whether a wedge of sphincter and ampulla actually is excised, whether the distal end of the main pancreatic duct is incised, or whether a long-limbed T tube is passed from the common duct into the duodenum and allowed to remain in place for several months after operation, are all technical considerations whose efficacy needs clarification. More time will be required for complete and final evaluation of sphincterotomy. Results of other surgical procedures leave much to be desired, and with the encouraging results obtained with sphincterotomy to date, it certainly appears to merit further usage.

Obviously any disease in the biliary tract should be corrected at the time of operation for relapsing pancreatitis. In order to prevent progressive damage to the pancreas it is important to prevent recurring attacks and not just to relieve pain. This means that operations merely for relief of pain (sympathectomy) should be reserved until after other procedures have failed and the pancreas has been functionally destroyed. The presence of complications such as stones in the pancreatic ducts, pseudocysts, or peripancreatic abscess requires an appropriate procedure to relieve the complication as well as a procedure to prevent recurring attacks of pancreatitis. Partial resection of the gland may be advisable in some cases when less radical measures have failed to provide relief. Resection of the tail or body of the pancreas has probably not been given a sufficient trial in such cases. Total pancreatectomy is indicated rarely.

In general it appears advisable to operate as early as possible in the course of relapsing pancreatitis. This is true for two reasons, (1) because progressive damage to the pancreas may be prevented and (2) because some evidence suggests that the results of surgical operation performed prior to the development of complications and extensive pancreatic damage are superior to those obtained at a later date.

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In Memoriam

EDWIN P. LEHMAN

1888-1954

EDWIN PARTRIDGE LEHMAN, a member of the Editorial Board of SURGERY since it first began publication in January, 1937, died in acute cardiac failure in Boston May 27, 1954. He was 65 years of age. He had been Professor of Surgery and Chairman of the Department, in the Medical School, University of Virginia, Charlottesville, Virginia, from 1928 to the time of his retirement Sept. 1, 1953. Even after his retirement, however, he retained an active interest in his profession and continued to attend meetings of societies of which he was a member. He was attending a class reunion at the time his last illness occurred.

He was born in Germantown, Pennsylvania, June 9, 1888. He was a graduate of Williams College and the Harvard Medical School, the latter in 1914. He had overseas medical service in World War I and then joined the staff of Washington University School of Medicine in St. Louis. He was successively resident surgeon, assistant, instructor, assistant professor, and associate professor of surgery. He served on the staff of the Barnes Hospital, the St. Louis Children's Hospital, the St. Louis Jewish Hospital, the St. Louis Maternity Hospital, the St. Louis City Hospital, and finally the University of Virginia Hospital, Charlottesville, Virginia.

His memberships, as well as local and state societies, included the American Surgical Association, vice-president in 1946, the Southern Surgical Association, president in 1948, the International Surgical Society, the American College of Surgeons, the American Association for the Surgery of Trauma, the Society of University Surgeons, and the Southern Medical Association, chairman, section on surgery, in 1933. He was also a member of the honor fraternities Phi Beta Kappa, Alpha Omega Alpha, and Sigma Xi. These and many other honors came to Dr. Lehman in a busy professional life.

Perhaps his greatest interest was in the field of cancer. He was director of the Virginia Cancer Foundation from 1940 to 1944, a long-time director of the American Cancer Society, its vice-president 1944-1945, and its president 1947-1948. He directed the Tumor Clinic of the University of Virginia from 1936, shortly after its establishment, until his retirement in 1953.

As is so frequently the case, however, facts and statistics do not give the full measure of the man. They fail to indicate the profound influence of the teacher in molding the undergraduate students, the important disciplines the surgeon imparts to the house officer, and as a result of these the part he plays in the lives of those he has trained.

Dr. Lehman's energy was boundless, his factual knowledge encyclopedic, his recollection of his voracious medical reading remarkable, and his intellectual integrity conspicuous. As a teacher he was meticulous and stimulating, as a writer and speaker he was clear and concise, as an administrator he demonstrated wisdom and responsibility, and as a surgeon he practiced the skills of his profession and endeared himself to his patients. As an associate he was without pomp and ostentation. Because of these and many other attributes, Dr. Lehman will be missed. No man is indispensable, or should wish to be so, but to some are given the capacity to so conduct themselves that they make an indelible impression upon their environment.

—C. Bruce Morton, II

ANNOUNCEMENTS

Buffalo Surgical Society

On Feb. 10, 1955, the Buffalo Surgical Society will sponsor the Roswell Park Lecture, this year to be given by Dr. Alfred Blalock, Professor and Director of the Department of Surgery, The Johns Hopkins University. Dr. Blalock at that time will be awarded the Society's Gold Medal given for the eighth time in honor of Dr. Roswell Park, Professor of Surgery at the University of Buffalo, 1883 through 1914. Previous lecturers and recipients of the medal are as follows: Dr. Allen C. Whipple (1948), Dr. Evarts A. Graham (1949), Dr. Dallas B. Phemister (1950), Dr. Frederick A. Coller (1951), Dr. Edward D. Churchill (1952), Dr. Warren H. Cole (1953), Dr. I. S. Ravdin (1954).

Sixth National Gastrointestinal Cancer Conference

On April 4 and 5, 1955, the Sixth National Gastrointestinal Cancer Conference will be held in New York City. With the New York Cancer Society acting as host, the Conference will meet in Hosack Hall at the New York Academy of Medicine, 5th Avenue and 103rd Street.

The conference is sponsored by the Gastrointestinal Cancer Committee of the National Advisory Cancer Council, National Cancer Institute, and is a continuation of the committee's activities in stimulating the interest of investigators in and disseminating information about the gastrointestinal cancer problem. Clinical aspects of the problem will be emphasized in the program of the conference. All interested scientists are invited to attend.

Correspondence

Ox Fascia in Hernia Repair

To the Editor:

I have read with great interest and appreciation the article by Usher, Morris, and Self, entitled "Lyophilized Human and Ox Fascia in the Repair of Hernias," which appeared in the July, 1954, issue of SURGERY. However, there are a couple of statements made by the authors which require some comment in order to get the record straight so far as ox fascia is concerned.

In speaking of ox fascia they stated that "there were many reports of wound infection, fascial slough, and recurrence of the hernia following its use." The authors did not cite any references for this statement. I know of only one such adverse report in the literature and that was made by Guy Horsley[1] in 1931. Horsley's paper reported experimental work in which he confirmed my experiments[2] on the fate of alcohol-preserved ox fascia lata in animals. He then reported five clinical cases in which there was apparently a sterile disintegration of the implanted ox fascia. His report came after his father, J. Shelton Horsley,[3] had been using ox fascia successfully for several years. These circumstances made me feel that something had gone wrong with the preparation of the fascia. I investigated immediately and found that there had been a manufacturer's error in the preparation of the material. The preserving fluid had been changed without consulting me. The company's chemist felt that if a solution was chemically correct, it was probably also biologically correct. This proved not to be the case. The new preserving fluid thoroughly sterilized the material, but the fascia put up in it proved to be very irritating to the tissues, and when implanted in animals a sterile abscess ensued with complete nonhealing of the wound. As soon as this was brought to the manufacturer's attention, the error was immediately corrected. However, undoubtedly a great many surgeons over the country did get some of this improperly preserved material, and the episode unquestionably resulted in a bad repute for ox fascia in some quarters.[4, 5]

The authors also stated that "Koontz later apparently gave up the use of ox fascia." This is correct. From the time that ox fascia was introduced[2, 6] in the middle 1920's until I went on active duty in 1940, I used the material extensively and successfully. However, there was one objection to it. There were more infections than when other suture materials were used. Burdick, Gillespie, and Higinbotham,[7] in a large experience with both autogenous and ox fascia hernia repairs, also found the incidence of infection higher when fascia was used, and found the incidence to be slightly greater with ox fascia than with autogenous fascia.

Since resuming practice after leaving the service in the spring of 1946, I have used ox fascia only once. This was in the case of a large muscle hernia of the thigh, in which I used a large sheet of preserved ox fascia with excellent results. About the same time, however, I began using tantalum gauze and found that it had the advantage that it did not give trouble in the presence of infection,[8] as was the case with fascia, either autogenous or preserved. It is possible that better results would be obtained with fascia of all sorts now than formerly, with the aid of antibiotics to prevent infection.

The contribution of Usher, Morris, and Self is most interesting and involves a study of the principles underlying the biology of fascia. Their initial results with lyophilized (freeze-dried) fascia have been good, but their oldest case is only five months old. Of sixty-three hernias repaired, there were three recurrences. One wonders whether infection

played any part in these recurrences, and whether the authors found infection to be as frequent in the use of their lyophilized fascia as others found it to be in the use of other fascia. Their subsequent reports will be awaited with interest.

Their technique of implanting the fascia using two strips at the same time and forming a latticework is a decided improvement over the older methods. Their method of placing these flat sutures a good distance from the edge of the defect is also an advantage and should result in less tearing out than is the case when sutures (no matter how wide) are placed near the edge of the defect.

—*Amos R. Koontz*
Baltimore, Md.

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